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MEASURING THE VALUE OF GRADUATE INFORMATION TECHNOLOGY EDUCATION FOR MARINE OFFICERS: A PROOF OF CONCEPT STUDY

by

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December 2002

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MEASURING THE VALUE OF GRADUATE INFORMATION TECHNOLOGY EDUCATION FOR MARINE OFFICERS: A PROOF OF CONCEPT STUDY

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This research examines a process to estimate the value of graduate education. Moreover, it demonstrates an approach to measuring the use of graduate education within organizations. Marine Corps officers who graduated from the Naval Postgraduate School's Information System Technology curriculum are studied. The study used a web-based survey for data collection and a Knowledge Value Added method to objectively estimate the value of education topics across different Marine Corps processes. Results indicate that the Information System Technology curriculum is designed and implemented to successfully meet sponsor requirements. It reveals that the education is highly valued and frequently used in post graduation billets. The most valued aspect of the education is theoretical knowledge. However, the research showed how practical information technology skills and social relationships that developed during the resident education were also highly valued and frequently used. The results go on to show that personal interest in education topics often corresponded to greater perceived value. Lastly, a proof of concept demonstrates a method to measure and compare the use on graduate education in subsequent organizational processes. The Knowledge Value Added method provides the ability to compare education use between different topics, across different jobs, and between different people.

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LIST OF ACRONYMS

Term	Definition
ASTD	American Society for Training and Development
BEEC	Billet Education Evaluation Certificate
C4	Command, Control, Communications, and Computers
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
DoD	Department of Defense
ESR	Educational Skill Requirements
HRM	Human Resource Management
I&L	Installations and Logistics
IST	Information System Technology
IT	Information Technology
ITM	Information Technology Management
KSA	Knowledge, Skill, and Ability
KVA	Knowledge Value Added
M&RA	Manpower and Reserve Affairs
MATCOM	Materiel Command
MCCDC	Marine Corps Combat Development Command
MCSC	Marine Corps Systems Command
MMOA	Manpower Management and Officer Assignments
MOS	Military Occupation Specialty
NPS	Naval Postgraduate School
OCCFLD	Occupation Field
P&R	Programs and Resources
PES	Performance Evaluation System
PP&O	Plans, Policy, and Operation

ROI	Return On Investment
SEP	Special Education Program
TECOM	Training and Education Command
TFSD	Total Force Structure Division
TFSP	Total Force Structure Process
TSR	Total Stockholder Return

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I. INTRODUCTION

This research examines a process to estimate the value of graduate education as it contributes to core organizational processes. The Marine Corps' process for providing for and employing graduate level education in the information technology field is examined as a proof of concept. Application of this model provides insight into the relationships between graduate level curriculum, adult learning processes, and organizational value. An increased understanding of these relationships contributes to the effective management of educational investments as well as to the design and administration of graduate level education programs.

A. LITERATURE REVIEW

The results of a review of the relevant literature concerning the value of graduate level education can be grouped into four categories: gross economic value, corporate return on education, training management, and performance studies. These collections of research each seek appropriate metrics and methods to determine the value of education from diverse points of view.

1. Economics of Education and Human Capital

The economic theory of human capital is based upon the idea that human beings are assets that have some tangible value. It is the human version of physical capital. Just like physical capital, investments in human capital can be evaluated based upon an anticipated flow of future income or on expected future value, in non-profit organizations like the military.

Organizations and individuals expend significant resources to acquire education. The time, energy, and money committed to graduate education presuppose a linkage to increased value of the educated person. The deliberate commitment of resources to achieve greater skill and knowledge is one of the fundamental premises of human capital theory (Schultz 1961; Becker 1975). This paper recognizes this fundamental theory and defines human capital as the amalgamation of a person's skills, knowledge, and talent.

Educational investment is but one type of human capital enhancement. The other principal ways to invest in human capital are through health and migration (Kiker 1971).

"Educational investment" is used loosely in this section to include the broader concept of learning. Learning is any process that changes a participant's attitudes, improves knowledge, and/or increases skills (Kirkpatrick 1998, 20). These knowledge, skills, and abilities are often abbreviated KSAs.

The examination of educational impact on human capital is not new. This field of study, as we know it today, was born more than thirty years ago. Table 1 presents the prominent studies on the contribution of education to human capital.

Theory	Explanation and Significance
Human capital investments result in increased future value (Becker 1975).	Presents one of the foundational theories of human capital investment. Examines the relations between earnings, costs, and rates of returns for learning investments.
Differentiation between public & private labor markets (Hinchliffe 1987).	Presents how internal labor markets in public sectors tend to focus on seniority, education, and cultural practices as opposed to productivity, which is more dominant in private markets.
Self-selection bias (Rosen 1987).	Presents a theory on the influence of personal choice in academic participation. Examines the difficulty of comparing the value of education based on the variably of students who participate. The pool of graduate students is not typical of the general, non-graduate, population.
Human capital investment processes and investment incentives (Shultz 1971).	Presents a theory of human capital investment that addresses the fundamental comparison between investing in men and investing human capital.
Exploration of shortcomings in earning based approach to measuring educational value (Solmon 1987).	Presents a range of variables that diminishes the validity of earning based measurements of educational impact.
Screening theory (Woodhall 1987a, 1987b).	Presents how the organizational value of educated workers is not solely based on academic achievement. Shows that academic achievement is often used as a filter to screen for human potential, independent of actual educational performance.

Table 1. Studies of Educational Investments in Human Capital

The authors highlighted in Table 1 have made significant contributions to the study of human capital.[1] They have advanced the general awareness and depth of study in this field, and their works have advanced the foundational theories of human capital.

[1] Schultz (1979) and Becker (1992) received the Nobel Prize in Economics for their work in this field.

These theories provide useful apparatus to analyze the general relationships between learning (as well as other factors) and human capital. However, these theories alone do not provide for the detailed analysis required to make specific decisions concerning organizational investments in graduate education.

2. Corporate Return on Investment

One attempt to provide decision makers with useful tools to administer training and education programs has been advanced by the American Society for Training and Development (ASTD). Founded in 1944, ASTD has served as one of the world's leading professional associations dedicated to the study of workplace training and education. In 1997, ASTD began providing organizations with standard definitions and metrics for measuring and valuing their investments in personnel erudition. In return for providing ASTD their training and education data, organizations receive benchmarking information that compares their investments across several reference groups (ASTD 2002).

The ASTD benchmarking database included training and education data from over 2500 firms. The data include such fields as training dollars per employee, type of training, and training delivery method. Over sixty percent of the firms are headquartered in the United States. Of the American firms, 575 are publicly traded. For these firms, training and education data are compared to the firms' subsequent year Total Stockholder Return (TSR).[2] In other words, ASTD examined how training investments in one year influenced TSR in the following year (Bassi 2000).

The analysis of data from 1996, 1997, and 1998 indicate that companies in the top quartile of training investment have higher median TSRs the following year; see Figure 1.

This benchmarking effort suggests a possible connection between investments in employee learning and a firms' net value. Presumably, the application of greater knowledge spawns increased innovation, efficiency, and/or productivity resulting in the firms' increased value. A correlation between employee learning and capital gains enable private organizations to justify their expenditures on employee education. Unfortunately, this benchmarking effort has not been applied to non-profit organizations because it is tied to stockholder return.

[2] TSR represents the change in stock price plus issued dividends for a given year.

Figure 1. Training and Developement Benchmarking Data (From: Bassi 2000)

The results of this effort support an intuitive notion that investing in employee learning should result in increased organization value, but this study provides no insight into how learning investments affect sub-corporate entities. Because TSR represents an aggregation of corporate data, the ASTD study does not provide a correlation between learning investment and organizational output below a corporate level. This ability to measure educational impact at sub-corporate levels is particularly required to target learning investments crafted to achieve precise process improvements by the educated employee.

Furthermore, this study is not able to show how changes in TSR are unambiguously related to investments in employee training and education. The computation of benchmarking data assumes that employee learning is the major cause of TSR change. This approach fails to recognize other factors that may also affect TSR, such as changes in personnel acquisition or downsizing, business practices and policy, and/or market trends.

The ASTD benchmarking project advances the practical aspects to calculating corporate return on learning investment. But by design, it fails to relate learning investments to sub-corporate level returns and does not provide the metrics to gauge return on education in non-profit organizations. Yet, the ability to manage individual investments and returns of employee education and training remains a high-priority

capability required by managers. This capability allows decision makers to optimize and justify investments in employee education and training against other competing investment requirements.

3. Managing Training as a Human Resource

Providing decision makers with tools and processes designed to manage an organization's human capital assets is one of the basic objectives of Human Resource Management (HRM). Human Resource Management encompasses many fields including recruitment and placement, training and development, compensation and motivation, appraisal and career management, and legal considerations (Dessler 1991). Each of these topics is supported by large bodies of research that deals with strategies geared towards improving organizational efficiencies. The following section reviews current trends and studies in HRM training and development as it relates to learning investments and potential returns.

a. Defining Learning

The phrase *training and development* are used in much of the human resource literature, while *training and education* are more commonly used in the military. In practical terms, both phrases describe a similar process—learning.

Training and education are two of the most commonly recognized endeavors to increase human capital. Often combined or used interchangeably, training and education usually differ in their processes and goals. Except where noted, this paper uses the Marine Corps' definitions of training and education, as defined below (Marine Corps 1999b).

> Training is the building in of information and procedures; using the progressive repetition of tasks, the product of training is skill development and proficiency. Training is performance based and is typically measured by objective standards.
>
> Education . . . is the drawing out of students to initiate the learning process and bring their own interpretations and energies to bear—the product of which is a creative mind. Educational objectives may be measured directly, but are often inferred from subjective testing or a sampling of student behavior over a period of time.

The main difference in these definitions emerges from the type of knowledge they seek to develop. Military training is generally geared towards increasing explicit procedural knowledge and reinforcing reliable application of skills. The desired outcome of training is consistent performance measured against established standards. Conversely, education seeks to instill an increased ability to apply concepts and skills in unstructured and unfamiliar situations. The results of education tend to be more implicit and more difficult to define as compared to training objectives.

When training and education are forged with experience, a more complete model of learning is created. Figure 2 presents a relationship of these three actions. This simple model identifies and relates the principle actions and outcomes of learning. Training tends to produce skills. The learner's experience provides greater context for the utilization of skills. Education advances the learner's awareness of cognitive concepts. While each of these elements increase a learner's human capital; collectively, they provide a synergy to achieve greater human potential.

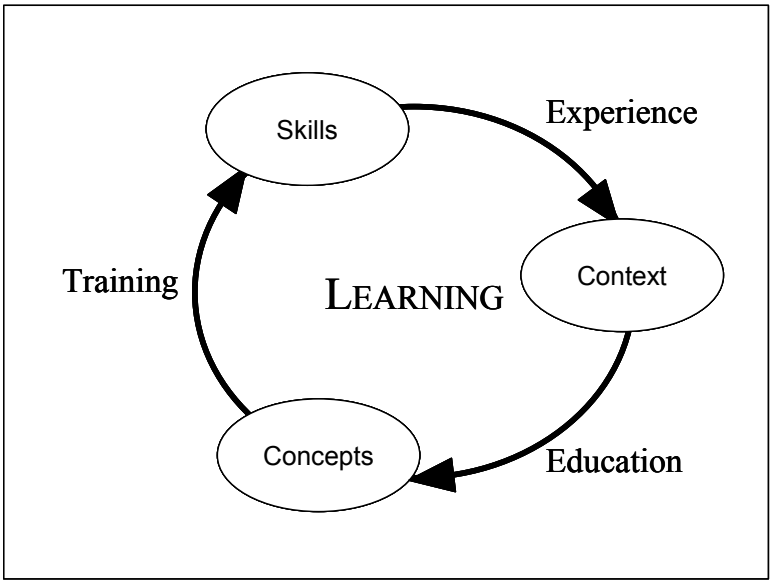

Figure 2. Learning Model (After: Oser 2002)

b. Training Evaluation

Human resource processes designed to measure the value of organizational training are relevant to this study and are reviewed in this section. Notwithstanding that human resource management primarily focuses on training as

opposed to education, the frameworks used to measure training value may also be appropriate to estimating education value.

Donald Kirkpatrick and Jack Phillips are recognized in the field of human resource management as two of the principal contributors of techniques to evaluate organizational training. Kirkpatrick was the first to articulate a model to assess the effectiveness of training (Kirkpatrick 1975).[3] In the 1990s, Phillips dominated much of the human resource development literature when he advanced Kirkpatrick's four-level model. He promoted a fifth level of evaluation to determine the impact of training. He called this fifth level of evaluation, training Return On Investment (ROI).

There are several strategies used to evaluate training. Table 2 presents four of the most prominent models. Examining these strategies reveals similarities in the evaluation approaches and objectives. They generally provide for end-of-training evaluations of the training program by the trainees in order to evaluate the administration of the training. They seek to determine the degree of training transfer—what the trainee actually learned—as a means of isolating the effects of the training. Lastly, to varying extents, they try to determine the impact of the training within an organization or process in order to make more informed resource allocation decisions. Phillips' five-level model is the most advanced and emphasizes the fifth-level—calculation of a monetary ROI from training. The remainder of this section focuses on Phillips' model and specifically examines his process to calculate a return on learning investment.

[3] This model was presented in a series of four articles in the *Journal of the American Society for Training and Development*, November 1959 through February 1960.

Four-Level Approach (Kirkpatrick 1998, 19-24)	**Five Levels of Evaluation** (Kaufman and Keller 1994)	**Context, Input, Reaction, & Outcome Approach** (Phillips 1997, 40-41)	**Five-Level ROI Framework** (Phillips 1997, 42-43)
1. Reaction 2. Learning 3. Behavior 4. Results	1a. Enabling 1b. Reaction 2. Acquisition 3. Application 4. Organizational Output 5. Social Outcomes	1. Context Evaluation 2. Input Evaluation 3. Reaction Evaluation 4. Outcome Evaluation	1. Reaction & Planned Action 2. Learning 3. Job Application 4. Business Results 5. Return on Investment

Table 2. Training Evaluation Models

c. Calculating Return on Training Investment

To advance his training evaluation model, Phillips focused upon articulating and advancing the fifth-level ROI step. This step represents a significant contribution to Kirkpatrick's classic four-level evaluation process. Phillips' ROI process model is presented in Figure 3.

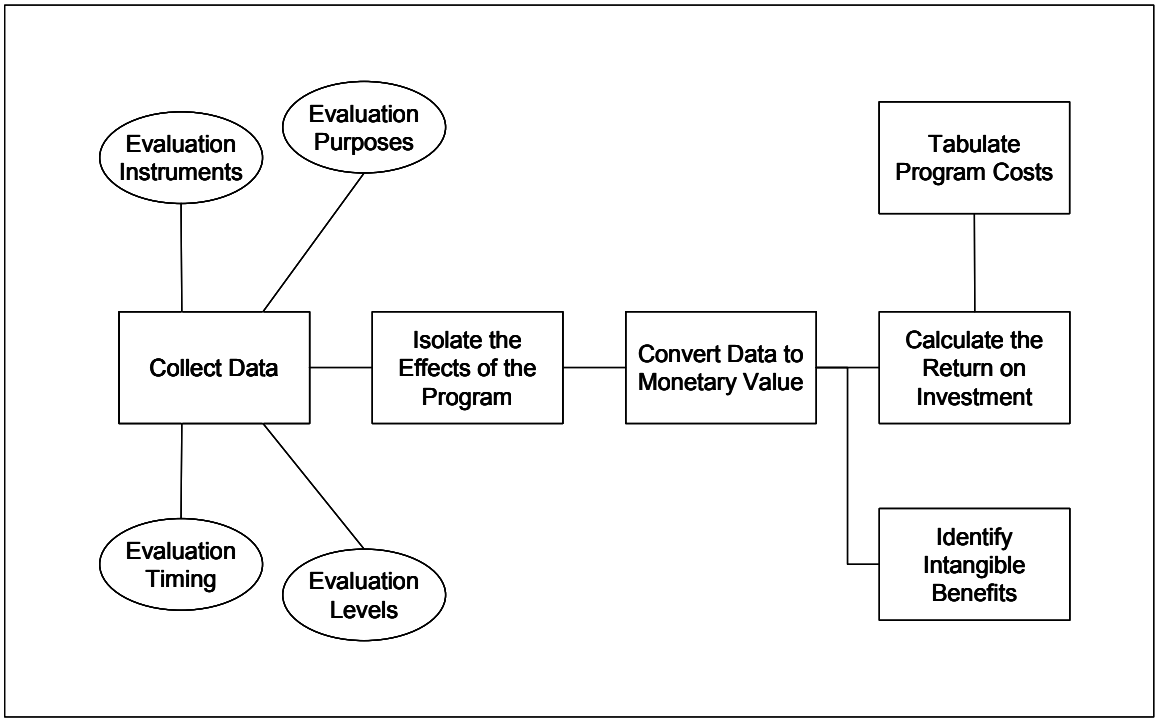

Figure 3. Training Return on Investment Process Model (From: Phillips 1998)

The four ovals in Phillips' ROI process model, shown in Figure 3, denote planning decisions required to prepare for ROI calculations. These four elements help shape how and what data are collected to begin the ROI calculation process. The data collection for this process is non-specific and can consist of any variety of methods ranging from surveys, to observations, to focus groups, as well as others methods.

Once data is collected, Phillips describes strategies to help isolate the effects of the training (Phillips 1998). These tend to be subjective assessments by participants, managers, and/or customers; and they generally describe the effects of training in such terms of changes in productivity, service, and quality.

The third step in the ROI model, shown in Figure 3, involves converting collected data to monetary value. This step is critical to continuing ROI calculations. The goal is to calculate an annual value for particular training. This involves assigning monetary values to training results such as increased productivity, service, and/or quality. Therefore, training value is derived from the estimated annual value of a training program for all program participants and is called the total program benefits (Phillips 1996). These program benefits can also be viewed as costs: costs that were avoided due to training.

To complete the ROI calculation, the cost of the training must be calculated. Tabulating training program costs includes all costs related to the design and delivery of the training. This includes instructor fees, various logistics fees, and the opportunity costs for the employees who attend training. The result of this step is the total organizational cost related to conducting the training program.

The training ROI is computed by dividing the estimated value of the training by the costs to perform the training. Comparing these training ROI ratios across different training programs provides insight into training program efficiency and effectiveness.

Phillips' ROI model is easy to understand and valuable as a tool to manage the administration of training programs. There is no reason that it could not be applied to calculate the performance of various graduate education programs. It provides a useful to for human resource decision makers. However, it fails to reveal how skills and knowledge affect organizational processes. This is a significant distinction—measuring

the efficiency of getting knowledge into an organization is different from measuring the efficiency of using the knowledge to achieve organizational objectives.

4. Surrogate Performance Measures

The last category in this literature review highlights studies that examine the value of graduate education within organizations. The primary subjects in most of these studies are naval officers who have graduate degrees from the Naval Postgraduate School (NPS), Monterey, California. These studies employ a variety of surrogate measurements to estimate the organizational impact of graduate education. In general, these studies explore relationship between graduate education and organizational rewards. Promotion and retention data are the most commonly used surrogate metrics. Table 3 provides a summary of these studies.

Study	Approach	Discussion
Relationship between on-the-job productivity and graduate education (Bowman and Mehay 1999).	Navy officers with funded graduate degrees. Data associated with promotion to O-4. On-the-job productivity is drawn from supervisor evaluations, specifically performance report assessment of "recommended for early promotion."	The research indicated that officers with graduate degrees were more likely to be promoted. Graduates of NPS had an increased likelihood. However, the research further indicated that a large part of the relationship between promotion and education is due to "unobserved attributes."
Economic returns of NPS education for Marine Corps officers (Branigan 2001).	Marine Corps officers with and without NPS degrees. Data associated with promotion to O-5. Value based on retention statistics and promotion rates to the grade of O-5 for officers with graduate degrees.	The research indicates that graduate education positively affects retention and promotion. Unable to isolate the attributes of NPS education from non-NPS graduate education.
Individual productivity related to graduate education [Cymrot 1986 (Branigan 2001, 12-14)].	Navy officers with funded graduate degrees. Time in previous grade (time to promotion) serves as an indicator of productivity—faster promotion is tied to increased productivity.	The research indicates that graduate education does not affect promotion rate (the productivity surrogate).

Effects of graduate education on productivity and job performance (Usan and Utoglu 1999).	Civilian Department of Defense (DoD) employees with at least a Bachelor's degree. Assumes that productivity and job performance are reflected in salary, promotion, retention, and performance rating.	The research indicates that graduate degree holders earn more, are more likely to promote, receive higher performance ratings, and are less likely to remain in the DoD.
Effects of graduate education on measures of job performance (Wielsma 1996).	Cohort of Marine officers commissioned in 1980 with and without graduate education. Data associated with promotion to O-4. Job performance is approximated from an average performance index. The performance index is calculated from fitness report ratings.	The research indicates that officers with graduate education have a higher average performance index. However, average performance index does not correlate to promotion.
Relationships between academic achievement and job performance (Wise 1975a; 1975b).	College graduates in a large manufacturing firm. Job performance is measured by changes in salary and grade level.	The research indicates that academic achievement is a significant determinant of salary and promotion. The research is unable to separate specific contributions of education from preexisting abilities.

Table 3. Studies Relating Education to Organizational Performance

While many of the studies in Table 3 use the term productivity, none provide an explicit definition. Most address the difficulty of providing a precise definition and explicitly assert that productivity is best measured by what an organization rewards. This assertion assumes that organizational rewards materialize in the form of promotions, retention, positive performance ratings, and increased salary (in private organizations). Recognizing a positive correlation between education and organizational rewards validates the basic assumption that an educated employee is a better employee. However, these studies do not help decision makers tease out direct, unambiguous contributions of graduate education to organizational processes.

The ability to estimate accurately and reliably the return on an educational investment remains an elusive problem. While this literature review reveals many approaches to measure the knowledge as an organizational capability, they fail to show how the *use* of these capabilities—graduate education in this case—directly affects core organizational processes. The number and variety of research approaches presented in this review highlight the far-reaching desire to gain additional insight into the dynamics between education and performance. To move beyond these approaches and evaluate the contribution of knowledge within an organization, two challenges must be resolved: an organization's graduate education objectives must be identified (how is it intended to be used) and actions that contribute to these objectives must be collected and assigned value in common units.

B. MARINE CORPS GRADUATE EDUCATION PROCESSES

This proof of concept deals with the value of graduate level education to the United States Marine Corps. The majority of the Marine Corps' fully funded graduate education is managed under the Special Education Program (SEP). The SEP seeks to align graduate education curriculums with the education requirements of specific billets or jobs. This curriculum-billet relationship tacitly demonstrates that the Marine Corps expects a specific impact to its core processes because of graduate education.

A procedure to estimate the return on educational investment is very appropriate to the Marine Corps SEP for two key reasons. First, graduate education is expensive. Perhaps the greatest organizational expense is the time that an officer spends away from the organization during education. However, the Corps continues to pay this expense with the expectation that the education will further enhance the organization. This prompts the second reason—without a means to estimate the return on educational investments, the Corps is unable to determine if its finite educational investments are being employed to greatest organizational advantage.

Responding to the first challenge could be solved in part by using a human resource approach to training return on investment such as Phillips'. This could help reveal how effectively Marine officers are being educated. But this approach fails to respond to the second challenge. Analyzing what, how, to what extent knowledge

investments contribute to process outputs requires a different approach. In other words, the approach must extend beyond managing how effectively knowledge is acquired and provide the tools to manage where and how knowledge makes the greatest impact.

In order to understand the implications of developing approaches to resolve these challenges, the SEP is described in this section.

The Marine Corps' SEP is chartered to manage the majority of the Marine Corps' graduate level education requirements and officer assignments. This program includes the validation and assignment of officers to roughly four hundred SEP billets. This section consists of a review of the SEP in terms of stakeholders, processes, and challenges. It is intended to present the current state of the Marine Corps graduate education environment. This background is important to understanding subsequent data collection, analysis, and recommendations.

1. Special Education Program Stakeholders

There are several stakeholders in the Marine Corps' SEP processes. In short, they are decision makers who perform specific functions to identify, validate, design, and/or evaluate graduate education programs.

- Education Providers are the accredited academic institutions (military and civilian) that provide graduate degrees to military officers.
- Manpower Management and Officer Assignments (MMOA) is the Marine Corps activity that assigns officers to billets. There is an officer in MMOA responsible for the assignment of SEP officers. This officer is commonly called the SEP Monitor.
- Owning Commands are commands that are authorized to maintain SEP billets. The number of SEP billets is fixed. For a command to gain a SEP billet, a command must relinquish an existing billet. There are seventy-eight owning commands in the SEP (Marine Corps 2000).
- Program Sponsors are military activities that sponsor graduate curriculums. They serve as the liaison between the military service and academic institutions. The Program Sponsors work with educational institutions to ensure that military requirements of graduate education are achieved. Program sponsors are usually Occupation Field (OCCFLD) Managers. These Marine Corps officers manage collections of similar Military Occupation Specialties (MOS). Twenty-six different MOSs are authorized at the completion of graduate education and carry a 96XX code. (Marine Corps 1993).

- Special Education Program Officers are officers who have applied and been selected to participate in the SEP. Acceptance into the SEP incurs a tour in a SEP payback billet and a four-year active duty commitment after graduation. The SEP process is designed to ensure that SEP officers are assigned to a SEP billet that corresponds to their education at the completion of their education. Some SEP officers serve repeated tours in SEP billets, but this is not a requirement of the program.
- Total Force Structure Division (TFSD) is the Marine Corps activity that manages the Corps' Table of Organization and Equipment. They are the approving authority for all personnel billets, including SEP billets.

2. Special Education Program Processes

There are several processes related to managing the Marine Corps' SEP. The stakeholders work together to accomplish these activities. In this paper, they are grouped along three functions to simplify their description: requirements, provisioning, and evaluation.

a. Requirements

The SEP process to identify graduate level education requirements is depicted in Figure 4. This figure shows the flow of actions to identify and validate Marine Corps billets that require graduate education.

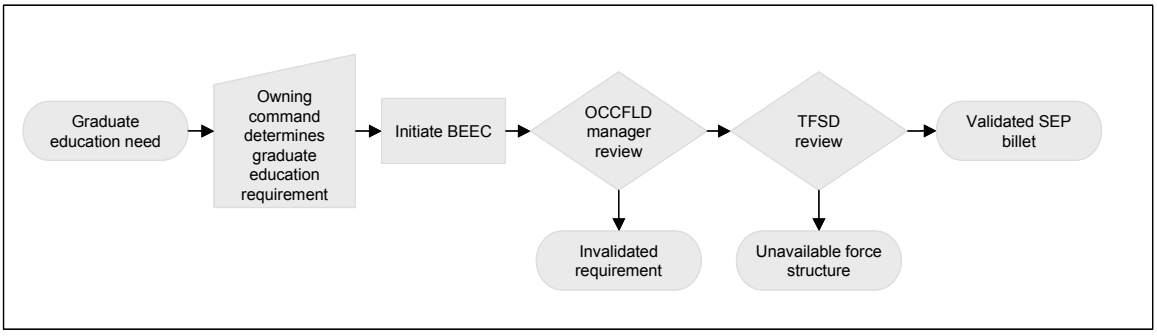

Figure 4. Identification and Validation of Graduate Education Requirements

There are two main parts in this requirements process. Billet Education Evaluation Certificates (BEEC) are used to describe the graduate education requirements for specific billets. These certificates are initiated by owning commands to articulate graduate level KSAs required in a specific billet. The education requirements are reviewed and validated by appropriate OCCFLD Managers. The TFSD performs the final approval for BEECs.

The Marine Corps Total Force Structure Process (TFSP) provides guidelines for managing the United States Marine Corps' manpower billets. This process designates TFSD as the manager of the Marine Corps' force structure. The TFSP prescribes how a command may request a change to an existing billet. The procedures to initiate special education requests using BEECs (described above) are explained in the TFSP (Marine Corps 1999a). Total Force Structure Division approval of a BEEC is required to authorize a SEP billet for a specific owning command.

b. Provisioning

The processes to identify SEP officers and manage academic programs are depicted in Figure 5. This figures shows the relationships between SEP stakeholders to accomplish the three main element of provisioning: requirements dissemination, student selection, and curriculum review. These responsibilities are shared between the military and education institutions.

Educational Skill Requirements (ESR) are the essential elements of an academic program defined by the Program Sponsor. An ESR is provided for each SEP curriculum and formally describes the education requirements from a military service perspective. Education institutions use the ESR to design academic programs to meet service education requirements. Education Skill Requirement documents may specify specific curriculum requirements in addition to describing the general intent of the education in terms of post-education application environments.

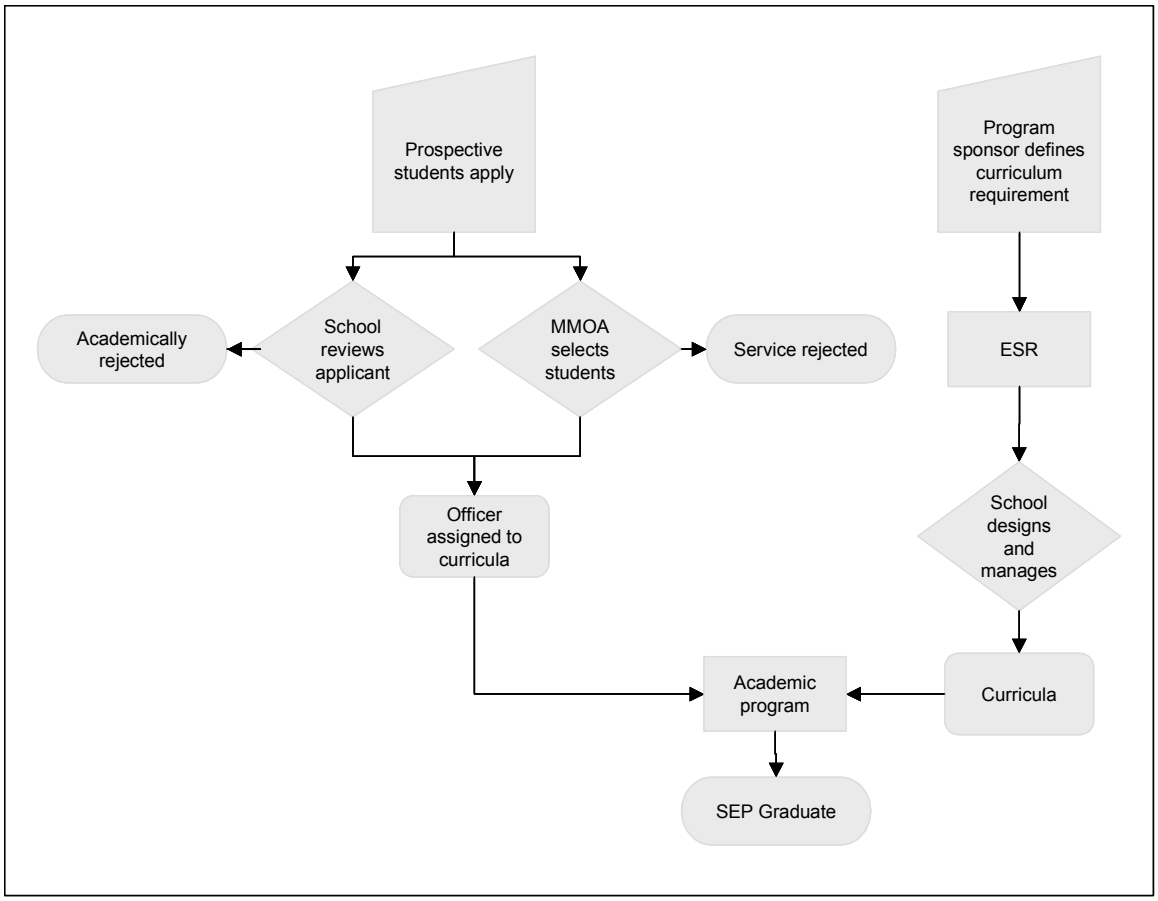

Figure 5. Selecting Special Educaiton Program Officers and Managing Academic Requirements

To maintain a flow of officers in the SEP pipeline, the Marine Corps solicits applicants for future-year SEP education opportunities. The appropriate education institution first reviews the potential SEP officer's application to make an academic acceptance decision. Applications that receive tentative academic acceptance are reviewed in a board process managed by MMOA. Applications that pass service requirements are assigned to SEP curricula based on the applicants' desires and the needs of the Marine Corps. (Marine Corps 2002)

The third part of the process consists of curriculum monitoring. Educational institutions conduct formal curriculum reviews on a recurring schedule. This review process involves the Program Sponsors and is geared towards aligning curriculum to ESRs. These reviews assess curriculum design and execution in terms of military service needs. Additionally, they evaluate curriculum resources and research efforts (NPS 2002a).

c. Evaluation

The Marine Corps process to evaluate the effectiveness of its SEP billet distribution is depicted in Figure 6. The process to evaluate the overall effectiveness of the SEP is the SEP billet review. The review is designed to optimize the distribution of SEP billets throughout the Marine Corps. The review has two specific objectives: identify the proper distribution of SEP billets across owning commands and identify the correct mix of graduate education disciplines. Stakeholders in the review process are MMOA, OCCFLD Managers, TFSD, and SEP billet owning commands.

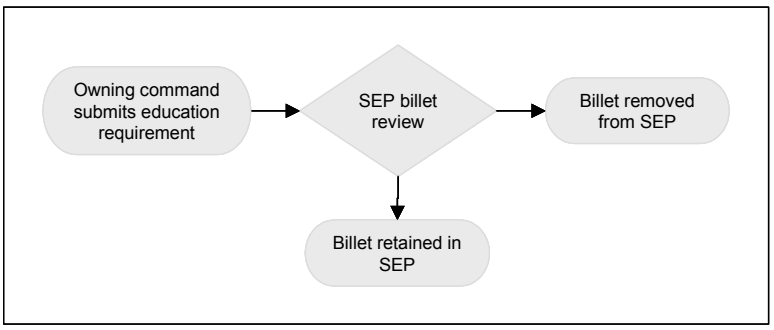

Figure 6. Special Education Program Billet Evaluation Process

This review process relies heavily on billet information provided in BEEC, as well as the judgment of the members conducting the review. The most recent SEP billet review stalled after two years of effort without substantial changes to the pre-existing SEP billet structure (Klinger 2002a; Marine Corps 2000, 2001, 2002). Completing this review process to adjust resource allocations is complicated by the wide breadth and diversity of SEP billets and owning commands. Furthermore, the reallocation decisions are based, in large part, on the limited information contained in the BEECs.

By its design and charter, this review process does not try to determine the demonstrated value of graduate education to Marine Corps processes. The process is solely based on pairing validated education requirements to specific owning commands. In taking this approach, The Marine Corps appears to assume that its investments in graduate education are providing value to the organization and that the Corps does not need to expend resources to quantify this supposed value. The SEP billet review is a requirements-based process that minimally considers feedback from actual graduate education application of SEP officers assigned to SEP billets.

3. Challenges to Assessing Graduate Education Value

The SEP processes to identify graduate education needs, influence educational processes, and evaluate SEP officer performance are generally effective but not managed to attain their fullest potential. High priority graduate education needs are identified and satisfied with the assignment of officers who have accredited education. The value of SEP officers to owning commands is demonstrated in part by the competition between commands to acquire and/or maintain SEP billets. The current processes have evolved to meet many of the Corps' graduate education requirements, but there remain shortcomings to these processes.

Many of these shortcomings are highlighted by the recent SEP billet review. The review consumed many resources and did not result in substantial realignment of SEP billets. This could indicate that the pre-review billet alignment was appropriate, or perhaps it signals that the reviewers lacked the appropriate tools to make more effective graduate education allocations. Furthermore, the billet review process is based on the documentation of requirements as opposed to demonstrated performance.

A Marine Corps process that links the skills and knowledge acquired during graduate education to improvements to and/or efficiencies in core processes does not exist. This capability would improve the Marine Corps' ability to effectively manage its limited population of officers with organizationally funded graduate education. The review of current Marine Corps SEP processes reveals several difficulties in the organization's ability to determine the value of its graduate education investments.

a. Consistent Measurement

The Marine Corps Performance Evaluation System (PES) is used to evaluate billet performance of Marines with rank from sergeant to general (Marine Corps 1998). As a single personnel evaluation system, the PES serves the Corps well. Because it is optimized to assess the general performance attributes of a wide range of Marines, the system does not ensure specific and standard insights into the impact of graduate education on billet performance. The system's inability to document the influence of graduate education is further limited by the inconsistencies of individual supervisor evaluations. Therefore, there is no specific process to assess the performance of officers in SEP billets.

b. Billet Lock-in

The process to prioritize SEP billets to achieve the greatest organizational value to the Marine Corps lacks responsiveness. Once a billet is designated with a SEP requirement, the removal of that designation is difficult. Because there are a finite number (about four hundred) of SEP billets, creating a new SEP billet requires the surrender of another. This fixed number of SEP billets often results in a battle between billet owners who seek to maintain their SEP graduates.

This battle would appear to validate the value of SEP officers to a command. However, the desirability of SEP billets is not solely based on the SEP officer's capabilities. Billets that require SEP officers are filled at a higher rate than many non-SEP billets. In other words, SEP billets ensure a higher probability of actually having an officer to fill a billet, regardless of whether the SEP officer's education is employed or not. The only process to prioritize SEP investments across the Marine Corps is a complete review of all SEP billets, and the various challenges related to this process were highlighted above.

c. Curriculum Feedback

The current processes used to manage the SEP have no direct Marine Corps feedback to post-graduate curriculum managers. This causes a lag in the SEP curriculums to meet dynamic graduate education needs. Additionally, it complicates processes that attempt to relate SEP billet performance to curriculum content. The absence of this feedback mechanism makes the use of learning evaluation methods more difficult and inhibits the ability of decisions makers to optimize educational investment.

C. RESEARCH QUESTIONS

The review of the relevant literature concerning the organization value of graduate level education reveals a variety of approaches to estimate the value of education within an organization. The existing body of research supports the effort to establish methods to connect investments in graduate education to organizational processes. Components of the examined studies take practical form in some of the Marine Corps' current management of graduate education programs. Based on the original thesis and results of this literature review, the following research questions precipitate.

- How well does the NPS Information System Technology (IST) curriculum meet Marine Corps graduate level Information Technology (IT) education requirements?
- What is the value of the IST education to the Marine Corps?
- How does the NPS IST curriculum improve productivity within Marine Corps SEP billets?
- What effect does personal desire have on education value?
- Is there a relationship between social connections formed during graduate education and subsequent productivity?
- Can a Knowledge Value Added method be used to assess the current value of graduate education?

II. DATA COLLECTION

This research provides a proof of concept for a method to estimate the value of graduate education. This chapter explains the methods implemented to gather the data used to develop this concept. The objective, scope, and instruments of data collection are addressed.

A. OBJECTIVE

Data collection focuses on gathering information appropriate to answer the research questions. These research questions are tied to determining the value of graduate education. In this study, the value of graduate education is assessed based on the impact of education to core organizational processes. The collected data collection is central to establishing connections between education use and changes in process output. Once established, these connections reveal what elements of graduate education are being used and what impact they generate.

B. SCOPE

Graduate education program, subject population, and education application define the scope of this investigation. The Information System Technology (IST) program at the Naval Postgraduate School (NPS) is examined. The subject population of this study consists of Marine Corps officers who have participated in the IST program. Lastly, the application of the IST education is limited to Marine Corps billets designated as requiring this education.

1. Information System Technology

The Naval Postgraduate School is the Navy and Marine Corps' corporate institution for graduate level technical education. The NPS offers an accredited Masters of Science in Information Technology Management (ITM) as part of its IST curriculum.

> This curriculum provides officers with the knowledge of information systems technology to include computer and telecommunications systems, software engineering, networked and distributed applications, database management systems, and decision support systems in the military services. Students . . . gain proficiency in information systems, economics and management necessary for the critical management decisions needed

> in the development and utilization of complex and evolving computer-based military systems (NPS 2002c).

This curriculum is designed to provide the education described by the various IST program sponsors. In practice, these skill sets usually exceed the scope of typical accredited graduate degree programs. To accommodate these additional skill requirements, the NPS supports curriculums that often exceed standard degree requirements in order to meet the totality of sponsor objectives. This responsiveness to sponsor requirements is the *raison d'être* of the NPS.

The distinction between the IST curriculum and the ITM degree is worth additional description to clarify the different objectives of the education. Successful completion of the NPS IST curriculum—the education that the program sponsor wants—provides an officer with the Marine Corps Military Occupational Specialty (MOS) code of 9648, Management, Data Systems Officer (Marine Corps 1993). On the other hand, the ITM degree—included as part of the IST curriculum and particularly valued by the student—represents only a part of the IST curriculum. In fact, the ITM degree requires only fifty-two credit hours of study and forms the nucleus of the 125 credit hours required by the IST curriculum (Cook 2002a).

The NPS ITM degree predates the current IST curriculum. The current IST curriculum evolved from previous curriculums to adapt to the changing program sponsor needs. The IST curriculum most correctly describes the educational requirements of the Marine Corps' program sponsor; however, the Marine Corps Special Education Program (SEP) commonly refers to the program as ITM. This is based on the foundational degree that predates the 9648 MOS producing curriculum.

a. Program Sponsor

The Program Sponsor influences the composition of the IST curriculum by describing education requirements. The Marine Corps' Program Sponsor for the IST curriculum is the Director, Command, Control, Communications, and Computers, Headquarters Marine Corps. The IST curriculum also has a Navy Program Sponsor, Director, Space, Information Warfare, Command and Control Division, Navy Staff. The Navy sponsor provides the bulk of the financial support related to the development and

management of the IST curriculum and subsequently sets the educational requirements for the IST curriculum. The Marine Corps sponsor has traditionally supported and accepted the Navy educational requirements and does not take an active role in affecting the overall design of the IST curriculum except where specific Marine Corps issues warrant differences.

To influence curriculum, the Navy Program Sponsor disseminates the Educational Skill Requirements (ESR) for the IST curriculum. The ESR articulates the Knowledge Skill, and Abilities (KSA) objectives of the curriculum. The IST ESR states that graduates should have the KSAs to engineer and manage information systems afloat and ashore. To realize the KSA goals, several areas are emphasized (NPS 2002b).

- Strategy and Policy—the ability to think strategically and discern the relationship between political interests and military application.
- Space, Information Warfare, and Command and Control Professional Practices
- Software Development—the ability to manage software programs.
- Information System Technology
- Information System Analysis and Management
- Military Application of analytical methods, technical expertise, and operational experience.
- Independent Research in the form of a thesis.

It is important to note that while development of the IST ESR is the responsibility of the Program Sponsor, the NPS takes an active role in advocating curriculum initiatives. The provider-based initiatives are negotiated with the Sponsor and often lead changes in the ESR and curriculum (Cook 2002a).

This ESR document constructs the foundation of the NPS IST curriculum. Because the Marine Crops has some specific educational requirements not resident in the Navy ESR, the IST curriculum for Marine students contains subtle differences. Adding or substituting existing NPS courses into the Marine specific curriculum resolves these minor differences.

b. Marine Corps Requirements

While the ESR process is used to articulate educational requirement to academic institutions, the only pseudo-formal method to identify educational requirements within the Marine Corps is through the collection and validation of Billet Education Evaluation Certificates (BEEC). As explained previously, the Marine Corps generally accepts the IST ESR that the Navy Sponsor develops. However, when asked how the Marine Corps could compile and articulate specific education requirements for the 9648 MOS, the 9648 Occupation Field (OCCFLD) Manager stated that he would have to query the existing 9648 MOS billet holders (Klinger 2002a). This would probably be accomplished using the existing BEEC format.

Billet Education Evaluation Certificates are designed to explain and justify a SEP billet's educational requirements; see format in Appendix A. A BEEC is required and associated with each SEP billet (Marine Corps 1999a). Marine Corps Curriculum Sponsor maintains a BEEC for each SEP MOS. The BEEC describes what subjects a curriculum should include. It also includes the educational justification for specific billet requirements.

By definition, BEECs for 9648 MOS SEP billets document the graduate IST education requirements of the Marine Corps. Collecting and analyzing the current 9648 MOS BEECs serves two purposes. First, the graduate education justification of each BEEC should describe a set of core processes that the billet holder will perform. Second, BEECs define the curricular components required to effectively function in the billets' core processes.

The 9648 MOS OCCFLD Manager, the owning commands of 9648 MOS billets, and the Total Force Structure Division, Marine Corps Combat Development Command, maintain BEECs for the 9648 MOS SEP billets. Existing file copies of the 9648 MOS BEECs are requested as part of this study's data collection to define the Marine Corps specific education requirements for its 9648 MOS SEP billets.

c. Information System Technology Curriculum

The NPS curriculum crafted to meet the IST ESRs is designed as an eight-quarter/two-year program. Within the general subject areas, students may take elective

courses to specialize their studies in fields such as networks and security. The curriculum also allows students to pursue dual degrees in related fields; however, dual degrees are usually restricted to students possessing strong undergraduate or graduate background in parallel disciplines. The default IST curriculum for Marine students is presented in Appendix B.

d. Information System Technology Curriculum Components

In this study, the IST curriculum is divided in two ways to assist in effective data collection. First, the results of the IST curriculum—learning—are viewed as providing the student with practical hands-on information technology skills, as well as, theoretical or conceptual knowledge relating to information technology. An explicit description of this division, as it relates to IST courses, is not discussed. However, this distinction will be highlighted during data collection and used to assess the relative weighting between skills and knowledge derived from the IST curriculum.

The second division of the IST curriculum breaks the courses into fourteen topic areas. Table 4 lists the topics and associates them with the default IST list of courses presented in Appendix A. The table also shows the associated course hours dedicated to each IST topic. The IST curriculum allows for elective study beyond the courses listed in Table 4, and these additional courses are associated with topics as they are revealed in data collection. These fourteen topic areas have been defined by the author and are consistent with the School's Department of Information Sciences Associate Chairman for Operations (Cook 2002a).

Topic	Courses	Hours
Acquisition/ Program Management	Principles of Systems Acquisition and Program Management	6
Command and Control	Introduction to Command, Control, Communication, Computer and Intelligence Systems in DoD Principles of Information Operations	9
Communication System Engineering	Computer Architecture and Operating Systems Introduction to Communications Systems Engineering for ITM Introduction to Communications Systems Engineering II Electronic Communications Systems for ITM	22
Computer Networking	Computer Networks: Wide Area/Local Area Process Re-Engineering with Information Technology C4ISR Systems	14
Computer/ Network Security	Information Assurance: Introduction to Computer Security	6
Database	Fundamentals of Database Technology	5
Decision Support Systems	Fundamentals of Decision Support Systems	5
Economic/ Financial Management	C4ISR System Evaluation Principles of Information Systems Evaluation Financial Management in the Armed Forces	10
Managing Change	Managing Planned Change in Complex Organizations Information Systems Management	8
Professional Military Education	Strategy and Policy: The American Experience	6
Software Engineering	Software Design Software Engineering and Management	10
Software Language Programming	Introduction to Object Oriented, Event-Driven Programming Using Microsoft Visual Basic	5
Space Operations	Space Technology and Applications Military Satellite Communications	6
Statistical Analysis	Statistics for Technical Management Operations Research for Computer Systems Managers	10

Table 4. Information System Technolgy Curriculum Topics

2. Subject Population

The subjects for this data collection are Marine officers who have the 9648 MOS. These officers have generally completed between four and twelve years of active duty service before attending the NPS. They volunteered for and were accepted into organizationally funded education in return for a commitment to apply that education in a SEP "payback" billet. They were assigned the 9648 MOS upon completion of their NPS curriculums.[4]

The population of SEP graduates used in this study is drawn from the Marine Corps Manpower Management and Officer Assignments database. The SEP Monitor maintains a list of 9648 MOS SEP officers dating bake to 1987 (Esparza 2002a). The list contains 122 officers. Current contact information is available for eighty-four of these officers.[5] These eighty-four officers form the pool of graduates surveyed in this research.

To assist in data collection and analysis, the population is divided variously. Collection instruments allow the subject population to be sub-divided by the five categories described in Table 5.

[4] Currently, the 9648 MOS is granted on completion of the NPS IST curriculum. Before 1998, the IST curriculum was simply called ITM. The ITM curriculum and degree were developed from a merger of Computer Systems Management and Telecommunications Systems Management in 1990.

[5] The Navy/Marine Corps White Pages Directory, http://sdiego.dir.navy.mil/basic_search_frameset.htm, was used to cross reference 9648 MOS officers with current e-mail addresses. Comprehensive look-ups were conducted in August 2002 and September 2002.

Category	Domain
Current Rank	Captain Major Lieutenant Colonel Colonel
SEP Billet Experience	Currently in first SEP billet Currently in second SEP billet Currently in a post-SEP billet SEP payback deferred until after current billet Never served in a SEP billet
SEP Billet Dates	Start and End Date of most recent SEP Tour
NPS Graduation Date	NPS Graduation Date
Education Specialty	No Specialization Decision Support Modeling and Simulation Networks Security Software Engineering Other

Table 5. Subject Population Categories

3. Education Application

Special Education Program officers are normally assigned to SEP utilization billets upon completion of their education. The Marine Corps has fifty-five billets currently certified for officers who have the 9648 MOS (Klinger 2002b). On rare occasions, graduates will not be assigned to one of these SEP billets due to manpower management considerations. Similar considerations may result in an officer deferring his SEP billet tour until after completing a non-SEP billet. Additionally, some officers may serve repeatedly in SEP billets. These 9648 MOS SEP billets tend to reside in the support agencies of the Marine Corps.

To delineate the central functions of these support agencies, the Marine Corps has specified several processes that are critical to the effective operation of the overall organization. These nine processes represent those specific organizational functions that

provide unique, value added benefits to an organization's customers—in this case, the warfighting entities of the Marine Corps. Table 6 presents these nine processes and identifies the process owners.

The fifty-five 9648 MOS SEP billets can be associated with the process owners listed in Table 6. This table summarizes the distribution of 9648 MOS SEP billets by their affiliation with the nine process owners. The detailed list of 9648 MOS SEP billets and specific process owner affiliation is presented in Appendix C. Within these nine Marine Corps processes, officers with the 9648 MOS generally support Information Management efforts. In this context, the NPS IST ESR broadly defines information management—to engineer and manage information systems afloat and ashore. Table 6 is intended to show how the Corps' educational investments in information management—principally, graduate education to produce officers with the 9648 MOS—are distributed across the Marine Corps agencies tasked to oversee the Corps' nine principle processes.

Marine Corps Process	Description	Owner	9648 Billets
Acquisition	Equip operating forces to accomplish warfighting mission	Marine Corps Systems Command (MCSC)	17
Training Development	Develop, coordinate, resource, execute, and evaluate training and education concepts, policies, plans, and programs	Training and Education Command (TECOM)	10
Human Resource Development	Plan, execute, and coordinate personnel policies	Manpower and Reserve Affairs (M&RA)	8
Resource Allocation	Financial policy, programs, and procedures	Programs and Resources (P&R)	5
Service Advocacy	Marine Corps participation in the Joint Strategic Planning System	Plans, Policy, and Operation (PP&O)	5
Total Force Structure	Allocate manpower and equipment to accomplish wartime mission	Marine Corps Combat Development Command (MCCDC)	5
Information Management	Plan, direct, coordinate, and provide oversight for all command, control, communications, and computers	Command, Control, Communications, and Computers (C4)	3
Infrastructure management	Logistics policy and management	Installations and Logistics (I&L)	1
Material Life Cycle Management	Ensure materiel readiness to the operating forces	Materiel Command (MATCOM)	1

Table 6. Marine Corps Processes (After: MCCDC 2002 and After: Klinger 2002b)

Table 6 provides a convenient means to group 9648 MOS SEP billets based on the Marine Corps allocation of these billets across important organizational agencies. Within this framework, data collection seeks to establish the impact of the NPS IST education on specific core processes within each of these nine process categories. The collection instruments used in this research seek to estimate education application by collecting seven different types of data relating to the IST education and subsequent SEP billet responsibilities. These collection types are presented in Table 7.

Collection	Objective
Education Requirements	Determine the knowledge and skills required to perform 9648 MOS SEP billet responsibilities.
Education Usefulness	Assess the relative importance of various IST education topics to 9648 MOS SEP billet responsibilities.
Education Interest	Assess the relative subject interest in various IST education topics.
Education Source	Assess the relative value of knowledge and skills to 9648 MOS SEP billet responsibilities based on formal education, self-education, and social contact.
Education Usage	Assess the relative frequency and significance of using various IST educational components to perform 9648 MOS SEP billet responsibilities.
Education in Support of Success	Estimates the demonstrated skills and knowledge that help achieve a 9648 MOS SEP billet success.
Impediments to Education Application	Estimation of impediments to the application of IST education in information technology initiatives.

Table 7. Collection Objectives

C. COLLECTION INSTRUMENT

A survey was designed to gather data on the application of IST education in follow-on billets. This survey was disseminated by e-mail to all 9648 MOS officers for which an address was available. This survey consists of a series of web pages that are made up of checkboxes, rating buttons, and short answers fields that populate a database. The survey response period was twenty-three days—19 September 2002 through 11 October 2002. The remainder of this section describes the format and objective of each survey page.

1. Respondent Information

The first page of the survey collects information about the respondent. In general, this information is used to sub-divide the respondent population based on the categories listed in Table 5. This survey page has four sections that are presented in Table 8. Data from this section are used to analyze response data based on various subject attributes.

Section	Rationale
Respondent information • Name • E-mail address • NPS graduation date	Record respondent information for further data collection. Graduation data are used to provide an option to divide population by graduation date.
What best describes your SEP experience? • Currently in first SEP billet • Currently in second SEP billet • Currently in a post-SEP billet • SEP payback deferred until after current billet • Never served in a SEP billet	Data used to sub-divide subject population.
Description of most recent SEP billet • Billet name • Command • Start date • End date	Billet data used to associate survey data with specific SEP billets.
To what extent did NPS provide the tools required in your SEP billet? • Seven rating buttons with a range from *Fully prepared* (7) to *Unprepared* (1)	Data used to assess the overall value of NPS education to follow-on SEP billet requirements.

Table 8. Survey Respondent Information

2. Naval Postgraduate School Education

The second page of the survey collects data concerning the respondent's education at NPS. It contains a series of checkboxes used to specify if and how the respondents specialized their NPS education beyond the default IST curriculum. Selections include Decision Support, Modeling and Simulation, Networks, Security, Software Engineering, and Other. In general, these data provide a means to sub-divide the subject population based on their specific educational background. Specifically, the survey outcomes are used to analyze a hypothesis that respondents place a prejudicial value on topics that they invested additional study.

3. Naval Postgraduate School Thesis

The third page of the survey collects data pertaining to the respondent's NPS thesis. The page consists of a series of text fields to gather information about the value of respondents' theses to the Marine Corps. Table 9 describes the survey page's three sections. While NPS theses are tied to the IST ESR as an educational objective relating to

research skills, these data are used to analyze the extent that IST theses provide direct value to the Marine Corps or other organizations.

Section	Rationale
What was your NPS thesis topic?	Records the respondent's thesis topic description.
Did the Marine Corps benefit from your NPS thesis by using it in some way? Yes. • Where and how was it used? Estimate the benefits to the Marine Corps or other organization • Cost savings (dollars) • Increase in efficiency (time saving) • Increase in productivity (increased output) • Improvement in quality • Other measure of benefit	Short answer data are used to assess how NPS thesis research positively affects the Marine Corps. These data serve two purposes. • Provide for valuation of NPS thesis independent of subsequent SEP billet. • Correlate thesis impact and subsequent SEP billet impact.
Did the Marine Corps benefit from your NPS thesis by using it in some way? No. Why was it not used? • Did not generate interest • Not a Marine Corps topic • Results not consistent with Marine Corps objectives • Other	Short answer data used to reveal why an NPS thesis does not add value to the Marine Corps.

Table 9. Survey Collection of Thesis Data

4. Education Usefulness

The fourth page of the survey collects data on the usefulness of IST education in post-education billets. Data consist of respondents' ratings across the fourteen IST topics as they pertain to SEP and non-SEP billets. The fourteen topics were described earlier in this chapter and relate specifically to the NPS IST curriculum. Table 10 describes the collection instrument. These data are used to assess the relative value between education topics.

Topics	Rating	Rationale
Acquisition/ Program Management Command and Control Communication System Engineering Computer Networking Computer/ Network Security Database Decision Support Systems Economic/ Financial Management Managing Change Professional Military Education Software Engineering Software Language Programming Space Operations Statistical Analysis	For each topic, IST program topics are rated in terms of their usefulness in SEP and non-SEP billets. For each type of billet, seven rating buttons are provided with a range from Critical (7) to Not critical (1). A non-applicable option is available if the respondent never studied the topic or if they never served in that type of billet. For each topic, a checkbox is provided to indicate if the respondent's knowledge of the topic was not provided by NPS.	Rating data are used to determine the usefulness of IST program topics to post-graduation assignments. The usefulness ratings are divided between SEP and non-SEP billets to assess variations in how education is used in different billets. Data concerning whether the topic was studied at NPS is used to explicitly tie the education to the NPS ITM education.

Table 10. Survey Collection of Education Usefulness

5. Interest in Topic

The fifth page of the survey collects data concerning the respondents' interest in particular IST curriculum topics. The page contains the same fourteen IST curriculum topics listed in Table 10. For each topic, the respondents rate their interest in the topic on a seven-point scale ranging from high (7) to low (1). Data from this page are used to examine potential relationships between respondents' ratings of topic usefulness and respondents' interest in topic.

6. Educational Value

The sixth page of the survey collects data on the value of the graduate education experience. The survey queries respondents to assess the relative value of practical skills,

theoretical knowledge, and social relationships developed during graduate education as they apply to SEP billet responsibilities. Seven rating buttons with a range from Critical (7) to Not critical (1) are provided in addition to a Non-applicable option. These three NPS artifacts (practical skills, theoretical knowledge, and social relationships) are further divided to determine the extent that the skills, knowledge, and relationships developed because of the NPS experience or due to the respondent's self-education. Table 11 describes the three sections of the survey page. These data are used to evaluate two questions.

Section	Rationale
Assess the value of practical, hands-on information technology skills to your SEP billet responsibilities.	These data are used to estimate the extent that practical information technology skills are important to 9648 MOS SEP billet responsibilities. The list of most valuable skills provides specific detail. The distinction between practical skill development at NPS and practical skills acquired on own is used to explore the settings where practical information technology skills are developed.
Assess the value of theoretical or conceptual Information Technology knowledge to your SEP billet responsibilities.	These data are used to estimate the extent that theoretical and/or conceptual information technology knowledge is important to 9648 MOS SEP billet responsibilities. The list of most valuable theoretical knowledge provides specific detail. The distinction between theory learned at NPS and theory learned on own is used to explore the settings where theoretical knowledge of information technology is developed.
Assess the value of your network of professional contacts that resulted from your NPS experience to your SEP billet responsibilities.	These data are used to estimate the extent that social relationships developing from resident NPS education have on 9648 MOS SEP billet responsibilities. The distinction between fellow students and NPS personnel is used to differentiate the types of social interactions that are useful.

Table 11. Survey Collection of Education Value

7. Education Usage

The seventh page of the survey builds upon the previous page and collects data on the significance and frequency of employing different education components listed in Table 12. It queries, "During your SEP tour, how often did you call on the following, and

how important was it?" Table 12 lists the educational components, rating options, and rationale.

Component	Rating	Rationale
Skills acquired at NPS Knowledge developed at NPS IST course material NPS resources like professors, staff, or current students Fellow NPS students	For each component, rate the frequency that it is used. Rating options include daily, weekly, monthly, quarterly, yearly, and never. For each component, rate the value of the component to your 9648 MOS SEP billet responsibilities. Seven rating buttons provide a range from Critical (7) to Not critical (1).	These data are used to compare education value and usage frequency. It provides for the collection of low value education components that may have high usage rates.

Table 12. Survey Collection of Education Usage

8. Billet Success

The eighth page of the survey collects data relating to successful SEP initiatives that can be traced, in part, to the respondents' NPS education. Data are used to identify core SEP billet processes and specific educational components that demonstrated value. The survey collects a description of the success, a description of the impact of the success on the Marine Corps, and an assessment of how NPS education aided in the success. The assessment provides for a description of employed skills, knowledge, and other education that helped achieve the success. These data are used to correlate the value generated in specific SEP billet actions to specific elements of NPS education.

9. Information Technology Failures

The ninth page of the survey balances the previous page by collecting data on failed information technology (IT) initiatives. Failures are limited to the respondents' 9648 MOS SEP billet experience. The survey collects a description of the failed IT initiative and the respondents' assessment of the reasons that the initiative failed. The reasons include failure to demonstrate value, funding, insufficient time, lack of organizational buy-in, technical complexity, training, and other. These data are used to analyze what 9648 MOS SEP billet factors prevent greater positive impact of graduate IST education.

10. Comments

The tenth and final page of the survey asks respondents if they are willing to conduct a follow-up telephone interview and provides a text field for additional comments.

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III DATA ANALYSIS

This chapter analyzes respondent survey data to answer the research questions.

A. LIMITATIONS

The survey achieved the collection objectives described in Chapter II. However, there are some inherent limitations to analysis based on the available data. Most of the limitations can be attributed to the primary data sources: Billet Education Evaluation Certificates (BEEC) and survey responses from Marine officers having the 9648 Military Occupation Specialty (MOS).

1. Billet Education Evaluation Certificates Data

The Marine Corps Total Force Structure Process mandates that all Special Education Program (SEP) billets have a validated BEEC. As explained in the previous chapter, a BEEC defines the graduate level education requirements for a specific billet or job. Fifty-five 9648 MOS billets require a BEEC; however, only twenty-four usable BEECs were collected.

While over fifty 9648 MOS BEECs were collected from the Program Sponsor and the Total Force Structure Division, more than half were dismissed due to age and duplication. The age cutoff used in this screening is five years, despite the requirement for bi-annual recertification.

Additionally, the specificity of the education requirements listed on the BEECs varies greatly. While some appeared thoughtfully developed, several simply stated that billet education requirements were equal to the Naval Postgraduate School (NPS) Information System Technology (IST) curriculum. In fact, one even called for the NPS Computer Science curriculum (which provides the graduate with a 9646 MOS). For these reasons, most of the collected BEECs fall short of complying with the Marine Corps' graduate education certification intent, and they do not meet data collection expectations.

The Program Sponsor stated that the BEEC validation process is very low priority and, in practice, does not inhibit SEP functions (Klinger 2002a). It is difficult to determine if the BEEC process is useful because it is simply not managed and enforced consistent with established policies. Data from the collected BEECs are considered

during analysis, but they are not valued strongly because they are incomplete and of inconsistent substance.

2. Survey Data

The web-based survey was disseminated to eighty-four marine officers who hold the 9648 MOS, and it collected responses for twenty-three days. The survey returned data from forty-four subjects—fifty-two percent. However, not every respondent completed the entire survey. Thirty-four and half percent or twenty-nine of the eighty-four subjects completed the entire survey. This response rate actually surpassed expectations; however, the responses are subjective and thus limit responsible analysis.

The survey responses contained an unexpected element that reduces the conclusiveness of some analysis. The survey responses proved very difficult to pair with available BEECs. Of the twenty-four BEECs used in this study, only half can be paired with survey respondents. These twelve BEECs associate with seventeen survey responses because several respondents held common billets. But most responses cannot be associated to a BEEC, so it is difficult to conclusively assess how well BEECs describe the education requirements for specific billets.

B. CURRICULUM FULFILLMENT OF EDUCATION REQUIREMENTS

The IST curriculum is tailored to provide graduate level Information Technology (IT) education to military officers. The Marine Corps articulates its graduate level IT educational requirements by specific billet. These education requirements are described using a BEEC for every billet requiring the 9648 MOS. It is reasonable to assume that the educational topics contained in the BEECs should resemble the course topics that make up the IST curriculum. Furthermore, survey data on the value of education topics in 9648 billets should be consistent with both the BEECs and the IST curriculum. A valuation of the IST curriculum can be assessed, in part, by how well it aligns with BEEC requirements and by testaments of officers who used the IST education in 9648 MOS billets.

1. Formal Education Requirements and Curriculum Composition

The fourteen education topics that make-up the IST curriculum meet nearly all of the education topic requirements listed in the twenty-four 9648 MOS BEECs that were collected in this study. Only one topic was listed on BEECs that are not part of the default IST curriculum courses: web application technologies. However, the Department of Information Sciences does provide elective courses on this topic. Notwithstanding this topic, these data support the assertion that the IST curriculum provides the education topics required by the Marine Corps. Figure 8 plots the frequency (by percent) that each of the IST education topics are identified on the twenty-four 9648 MOS BEECs.

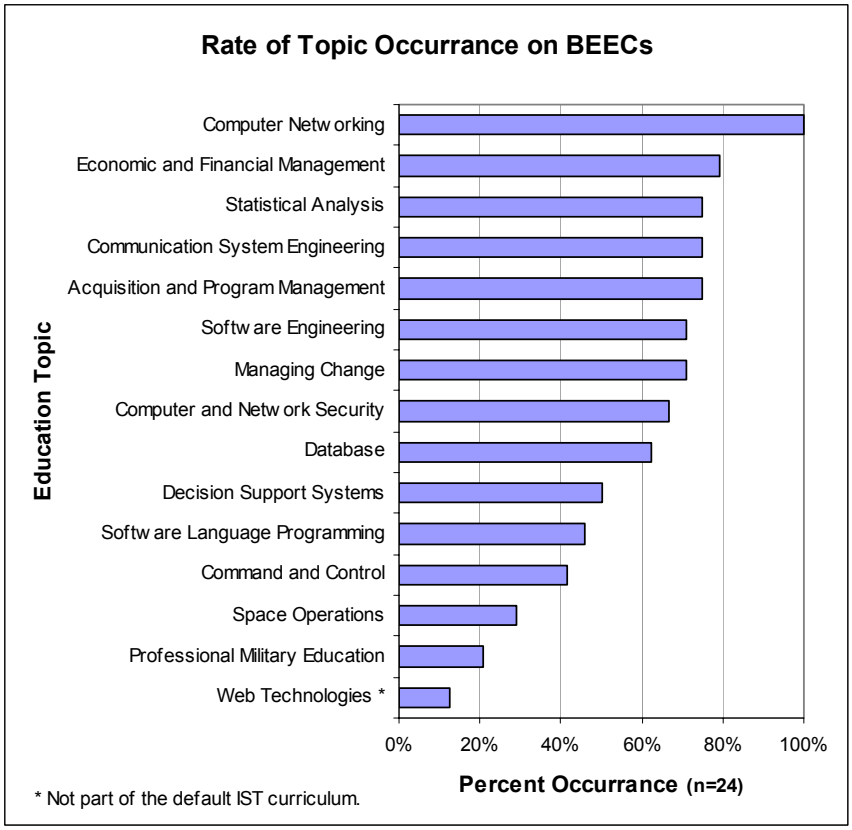

Figure 8. Rate of Topic Occurrence on Education Certificates

While Figure 8 indicates that the IST curriculum includes most of the education topics required by the Marine Corps, it does not reveal how well the curriculum meets these requirements. If the IST curriculum is tuned to meet the education requirements contained in the BEECs, it is reasonable to expect that the curriculum time devoted to each education topics should be roughly proportional to the BEEC occurrence frequency.

Figure 9 depicts this relationship and reveals that the IST curriculum is not uniformly proportioned to meet the aggregate BEEC education requirements. Figure 9 plots the difference between education topic occurrences from the BEECs and the number of IST course hours devoted to each topic (topic occurrence frequency minus total topic course hours). It highlights three conditions where BEEC education requirements are under represented, balanced, and over represented by the IST curriculum. There is no explicit value used to differentiate between the balanced and unbalanced conditions, but rather the figure serves to highlight the relativity of the differences.

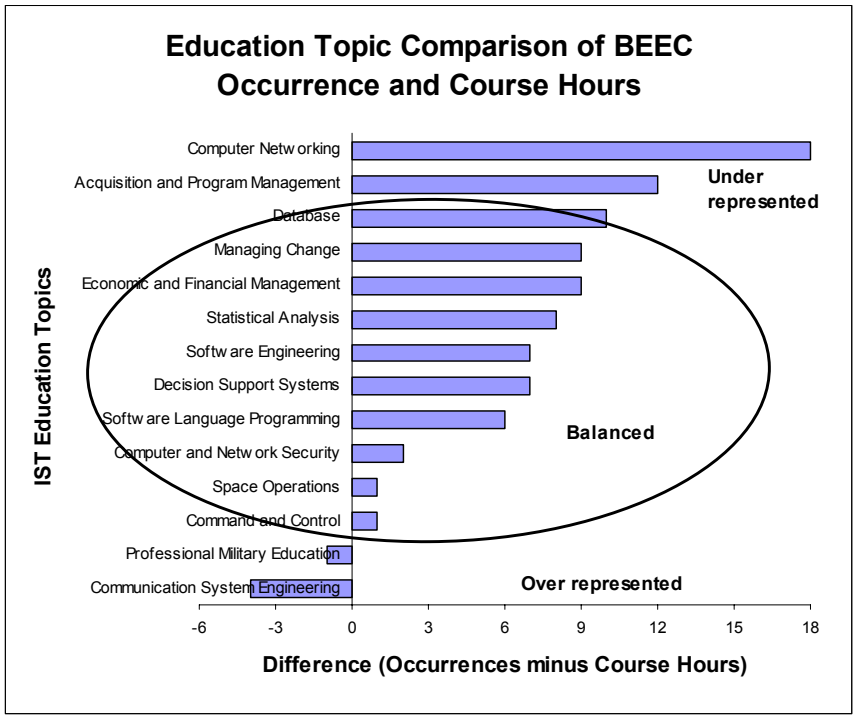

Figure 9. Comparison of Education Requirements and Curriculum Course Hours

It is important to note that the data supporting this graph is not normalized and is not expected to show centrality about zero. Additionally, this comparison assumes that meeting education topic requirements can be achieved in a common number of course hours, regardless of topic. However, it is sensible to assume that high-frequency requirements should receive higher curriculum weighting and suggests that differences larger than about five indicate less than appropriate alignment.

Figure 9 shows that most of the IST topics are balanced. It also reveals that Communication System Engineering receives significantly more emphasis in the IST curriculum than expected from the stated requirements. Likewise, two topics do not appear to receive the course hour weighting appropriate to the BEEC requirements.

2. Graduate Assessments and Curriculum Composition

Thirty-eight survey respondents rated the usefulness of the fourteen IST education topics. Figure 10 plots the average respondent rating by topic; there are no significant outliers in the response data. This figure reveals that the topics of the IST curriculum meet the Marine Corps' 9648 MOS education requirements, this time described by survey respondents.

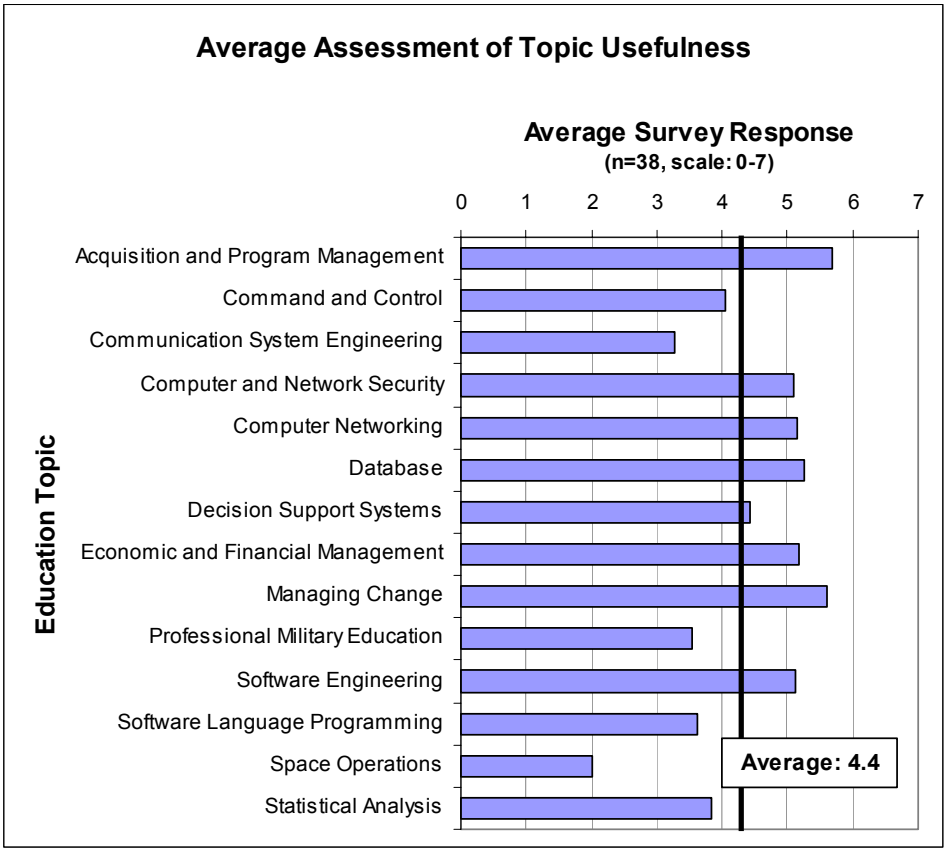

Figure 10. Respondent Assessment of Topic Value

Figure 10 indicates that Acquisition and Program Management is the most useful education topic in 9648 MOS billets; conversely, Space Operations is the least useful. Similar to the comparison in Figure 9, Figure 11 plots the comparison of these average ratings against the number of course hours in each IST topic. In this graph, course hours

have been divided in half to help normalize the data for comparison. It highlights three conditions where BEEC education requirements are under represented, balanced, and over represented by the IST curriculum.

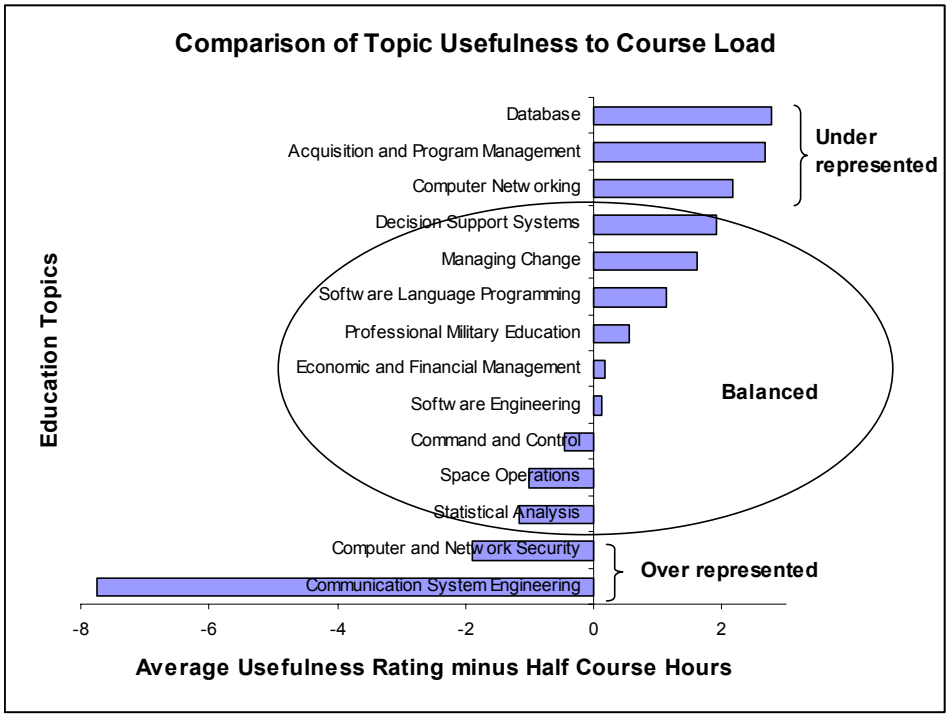

Figure 11. Comparison of Average Topic Value and Curriculum Course Hours

Upon reviewing the plots in Figure 9 and Figure 11, several similarities become apparent. Using two different methods to identify education requirements (BEECs and survey responses), the IST curriculum course hours appear proportional to about half of the education requirements. Most striking is the education topic that is significantly over represented in both comparisons: Communication System Engineering. Interestingly, the Department of Information Sciences is currently redesigning the Communication System Engineering education topic, and the course hours devoted to this topic will be cut by nearly fifty percent. The decision to redesign this topic resulted from a student-led effort that demonstrated low usage of communication system engineering by curriculum graduates.

While somewhat less conclusive, these figures also suggest topics that may be under represented in the IST curriculum. In both comparisons, Acquisition and Program

Management, Computer Networking, and Database rank as the top three topics where requirements exceed the course hour allocation.

It should be remembered that these comparisons are not expected to align completely. Furthermore, both the BEECs and survey responses have an historical bias. In the case of the BEECs, the certification of the requirements takes several years. Similarly, but to a lesser extent, survey respondents assessed the education topics based on their 9648 MOS billet experience, which tends to be a few years old. Moreover, the IST curriculum is current and evolving to provide education that will be used in the future. Therefore, it must be acknowledged that the Department of Information Sciences tries to anticipate emerging education topic requirements and factors these projections into curriculum design, which could explain some of the comparison disparities.

C. INFORMATION SYSTEM TECHNOLOGY EDUCATION EFFECTS

The Marine Corps' continued investment in the NPS IST curriculum suggests that the Corps perceives a positive organizational impact stemming from this educational investment. In fact, curriculum enrolment has increased over the past several years. Survey data allows for the effects of IST education to be analyzed in the three domains where it affects the Marine Corps: pre-graduation, SEP billets, and non-SEP billets. The survey data suggest that the IST curriculum can and often does positively affect the Marine Corps in each of these domains.

1. Pre-graduation Effects of Education

Officers in the IST curriculum can affect the Marine Corps through their thesis research. However, thesis research provides little value to the Marine Corps when the research is not sponsored. Twenty-one respondents indicate that their NPS IST thesis provided no value to the Corps. Two elements are common in eighteen of the twenty-one responses: the Maine Corps did not sponsor the thesis and/or the thesis topic was not related specifically to the Marine Corps. Seven other respondents indicate that they do not know if their thesis work provides value to the Corps. It is reasonable to suspect that their efforts were of no significant benefit to the Marine Corps.

However, there are fourteen cases when respondents felt that their NPS thesis research did provide value to the Marine Corps. The trend in each of these cases is that

the thesis had a Marine Corps or other Marine Corps supporting activity sponsoring the research. Of the respondents that believe their thesis provided value, the type of value broke down as follows.

- One thesis produced a scheduling tool that has been deployed to Marine Corps recruiters. The respondent estimated that the tool saved every recruiter sixty hours a year. Conservatively, this translates to between four and five hundred dollar of salary cost saving per recruiter per year. Perhaps more significant than the salary cost, the time saved provides the recruiter more time to focus on his mission and locate higher quality recruits for the service.
- Three theses provided value buy aligning thesis study with follow-on billet assignment. In these cases, the value resulted from increased efficiency when the officer arrived at the billet. While it is difficult to assign a value to this, it clearly speeds the time required to transition into a new position, which suggests greater overall productivity.
- Three theses provided value by supporting concurrent Marine Corps activities involving planning and studies. In these cases, the Marine Corps avoided costs by using thesis work instead of external consulting.
- Four theses provided indirect value to the Marine Corps by advancing research efforts by activities that support the Marine Corps. The value of these efforts are found in the Marine Corps ability to influence advanced research through the use of Marine officers who retain a vested interest in the research and who retain the research knowledge for subsequent assignments.

These analyses suggest that the Marine Corps could better leverage the potential to attain greater value from NPS theses by providing wider sponsorship. Currently, there is no Marine Corps activity that channels research requirements to Marine students at the NPS. Most thesis sponsorship develops from student-initiated contact with potential sponsors.

2. Curriculum Effects on Designated Information Technology Billets

Analysis indicates that the IST curriculum contributes positively to graduates' performance in 9648 MOS billets. This should not be surprising because these billets have been certified as requiring specific elements of the IST curriculum. While survey data cannot show specific effects, it is reasonable to conclude that survey responses that ascribe high value to elements of the IST curriculum, as they affect 9648 MOS billet responsibilities, should favorably affect the Marine Corps. The values of several different elements of the IST curriculum are presented in this section.

Seventy-three percent of survey respondents reported that the IST curriculum adequately prepared them for their subsequent 9648 MOS responsibilities. The response options for this query consisted of a seven-point rating scale with seven representing "fully prepared" and one representing "unprepared." The term adequately is used to describe response ratings of five, six, and seven. The distribution of these ratings is plotted in Figure 12.

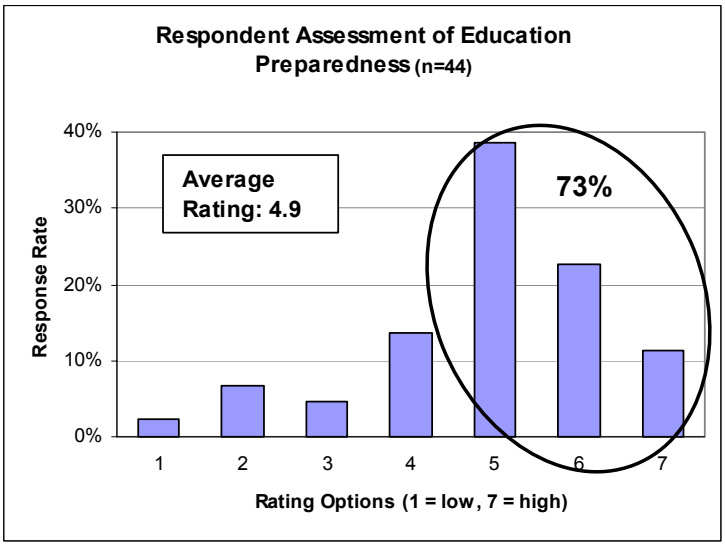

Figure 12. Respondent Assessment of Education Preparedness

Survey respondents were also asked to evaluate each IST curriculum topic with respect to their 9648 MOS responsibilities. These data were presented in Figure 10 by the value ascribed to each education topic. Figure 13 plots the distribution of the same response data in an aggregated form.

Figure 13 reveals that fifty-seven percent of the IST curriculum topics were useful to respondents' 9648 MOS responsibilities. Fifty-seven percent seems to suggest that the education topics are not particularly useful. However, these ratings account for all fourteen education topics, many of which were not highly valued. To help place this analysis in context, Acquisition and Program Management was the most highly valued education topic; eighty-four percent of respondents reported high value for this topic. On the other extreme, Space Operations received the lowest value rating; only sixteen percent of respondents reported high value. Therefore, the fifty-seven percent rating

across all topics indicates that most of the IST education topics are useful in 9648 MOS billets.

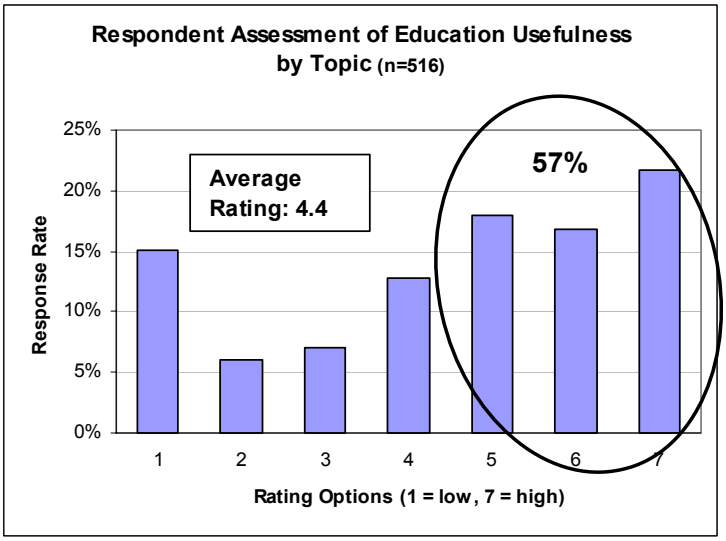

Figure 13. Respondent Assessment of Education Usefulness by Topic

It is not surprising to see that individual IST curriculum topics are not consistently useful across all 9648 MOS billets. The IST curriculum is designed to meet a broad set of learning objectives. Central to the curriculum is the goal to provide students with theoretical knowledge relating to information system technology. Figure 14 plots the distribution of survey respondent assessments of how well the IST curriculum achieves this goal. The response data overwhelmingly suggests—eighty-five percent—that the IST education provides *knowledge* that is valuable to subsequent 9648 MOS responsibilities.

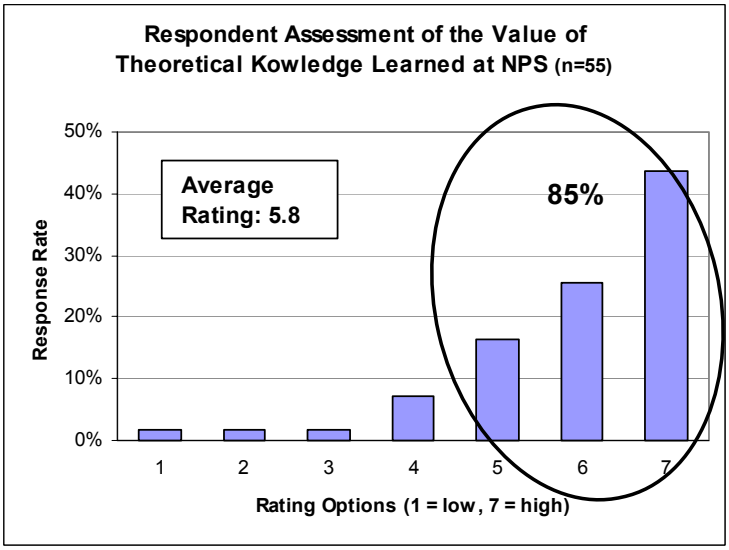

Figure 14. Value of Theoretical Knowledge

A secondary objective of the IST curriculum is the development of practical information technology skills. While subordinate to developing theoretical knowledge, these skills also provide value. Figure 15 plots the distribution of survey respondent assessments of how well the IST curriculum achieves this goal. With nearly the same enthusiasm as the previous figure—seventy-four percent—respondents report value to their 9648 MOS responsibilities from practical skills acquired at NPS.

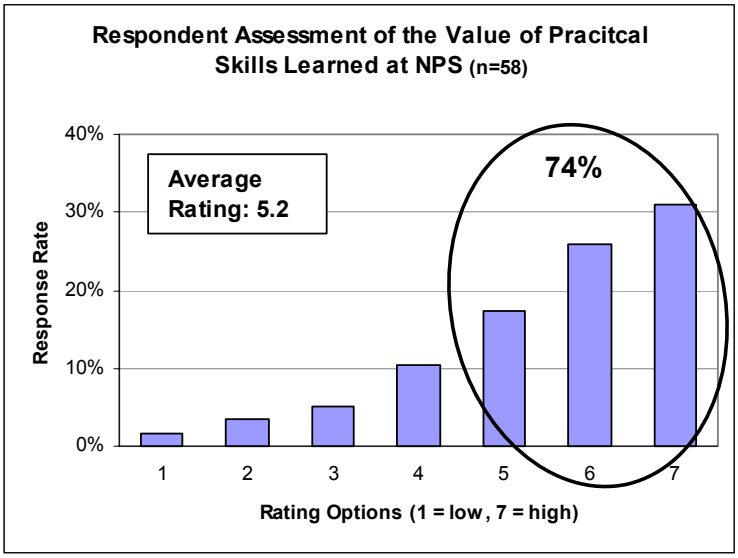

Figure 15. Value of Practical Skills

A final indication of the value of the IST education to the Marine Corps can be established by determining how often the education is actually used. Figure 16 plots the distribution of respondents' assessment of education usage frequency. It indicates that more than sixty percent of survey respondents feel that they use the knowledge and skills acquired from the IST curriculum on a daily basis. This high rate of usage coupled with the high value assigned to the IST education (Figure 14 and Figure 15) demonstrates the clearest example, from the available data, that the NPS IST education significantly impacts the Marine Corps 9648 MOS billets.

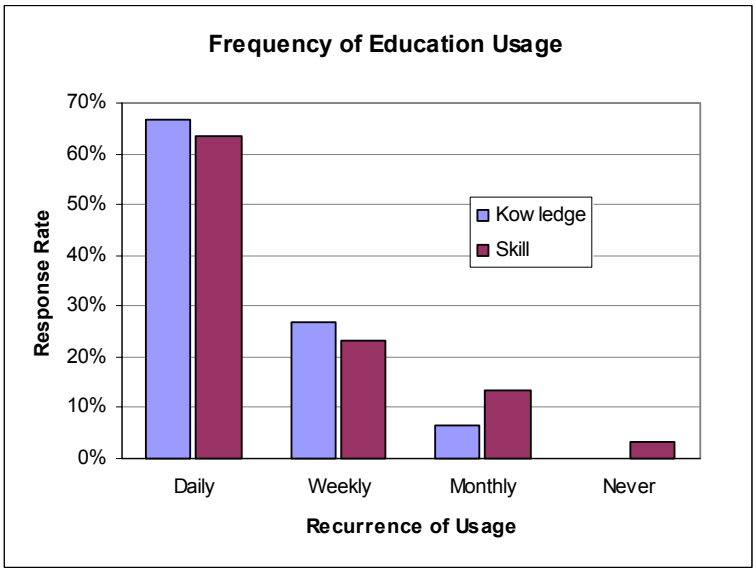

Figure 16. Respondent Assessment of Education Usage

A final way that respondents indicated how the IST education positively affected the Marine Corp is through descriptions of their successful information technology initiatives. Thirty respondents indicted that they were responsible or contributed to successful information technology initiatives as part of their 9648 MOS billet. The types of successes range from improved service, to better acquisition, to effective transition. While the survey did not capture the monetary value of these successes, the complexity associated with modern military information system technology suggests that the IST education contributed to the eventual success of each of these cases.

The analysis described in this section seems to validate the Marine Corps management of its graduate level information technology education. Despite the fact that there is not a responsive feedback mechanism in place to determine how well these

education investments affect the organization, these analyses suggest that the graduate education requirements and provisioning mechanisms achieve most of the service objectives.

3. Effects of Education on General Billets

The benefits of the IST education are not solely tied to 9648 MOS billets. Many officers with the 9648 MOS return to their primary MOS. This section reveals how the IST education is valued in these non-9648 MOS billets. While the previous section demonstrated that the IST education provides substantial value to 9648 MOS billets, this section shows how this value does not significantly fade in other MOSs.

Figure 17 plots the distribution of respondents' assessment of education topic value to non-9648 MOS billet responsibilities. This figure is similar to Figure 13, except it references non-9648 MOS billets. Perhaps not surprisingly, it indicates that IST education topics are generally not as useful in non-9648 MOS billets. It shows that only forty-six percent of the respondents felt that IST topics were valuable in these billets compared to the fifty-seven percent who felt that the topics were valuable in 9648 billets.

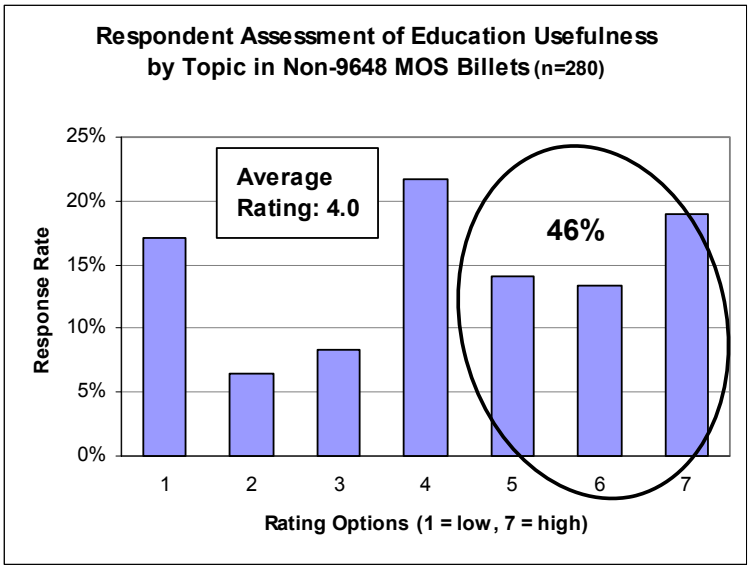

Figure 17. Assessment of Education Usefulness in Non-9648 Billets

While there is generally a lower value placed on topic value in non-9648 MOS billets, there is a significant similarity between the ratings. When comparing the value of education topics to 9648 and non-9648 billets the figures indicate that sixty-seven percent of the 280 ratings agree to within one rating point.

The most interesting piece of data from this comparison is the identification of IST education topics that were ascribed with equal or greater value in non-9648 MOS billets than in the 9648 MOS billets. When the average education topic ratings for 9648 and non-9648 MOS billets are compared, five topics have a difference that shows greater value in non-9648 MOS billets: Professional Military Education, Command and Control, Computer Networks, Communications Engineering, and Space Operations. However, closer review of these relationships seems to indicate that these rating differences may stem from low 9648 MOS ratings as opposed to high non-9648 MOS ratings. In other words, these topics were generally rated low in both categories, whereas the other topics were rated high for their value to 9648 MOS billets.

D. EFFECT OF PERSONAL PREFERENCE ON VALUE

Education value varies by perspective. The value of education within an organization may be different from the value placed on the education by an individual. Furthermore, a student's personal preferences may influence both the student's and the organization's assessment of education value. This research has demonstrated some significant similarities between the education topics valued by the organization—requirements—and personal testaments on the value of those topics. This section compares survey respondents' assessments of education topics and their personal preferences for those topics. Two methods are used to determine personal preferences: curriculum specialization and respondent ratings of topic interest. This analysis shows that individuals place higher value on education topics that they have a personal interest in studying. The results of this analysis suggest that greater personal value, and potentially greater organizational value, can be achieved by allowing students flexibility in the composition of curriculums.

1. Student Interest in Education Topics

Thirty-seven survey respondents rated the fourteen IST education topics in terms of their value to 9648 MOS billets and in terms of the respondent's personal interest in the topics. There was a moderate correlation between respondents' assessments of topic value and interest. Two graphs are used to present these relationships.

Figure 18 plots the mathematical difference between education topic interest and value rating. Based on the seven-point survey rating scale, differences can range from plus-seven to minus-seven. The figure reveals that there is little difference in respondent ratings of topic interest and value. In fact, sixty-five percent of the differences are one point or less, and the average difference is only three tenths of a point. While this figure shows part of the relationship, it does not specifically indicate how preference in an education topic affects perceptions of value.

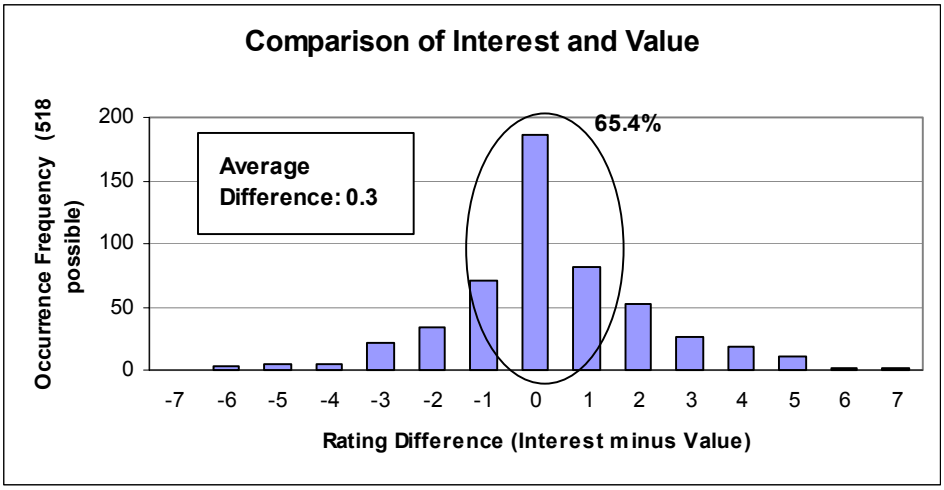

Figure 18. Difference in Value and Student Interest of Education Topics

Figure 19 plots the average value of education topics based on respondent interest ratings. It reveals that topic value is consistently higher when respondents assess high personal interest in the topic. While interest alone does not predict value, the relationship suggests that positive or negative student interest in education topics do have similar effects on value assessments. In this example, there is an eighty-nine percent chance that a topic will receive a value rating of five or greater, given an interest rating of seven. Conversely, there is only a twenty-three percent chance that a topic will receive a rating of five or greater, given an interest rating of three or lower.

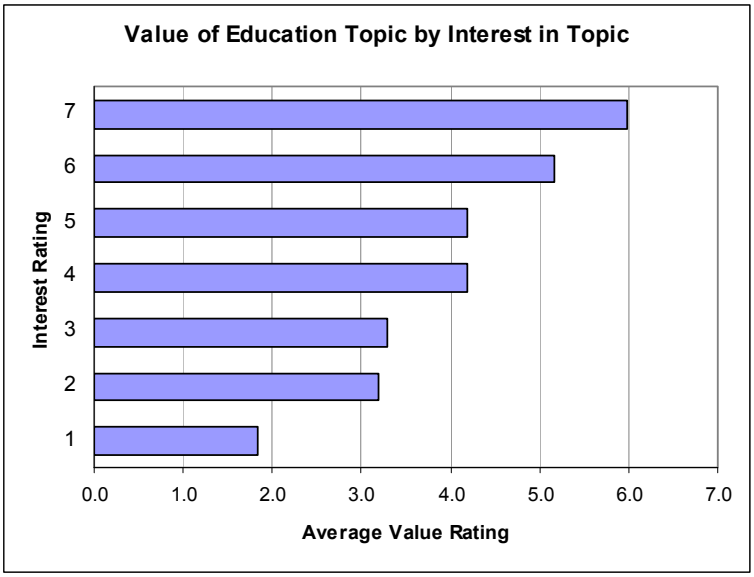

Figure 19. Education Topic Value by Student Interest in Topic

2. Student Investment in Education Topics

The IST curriculum allows students a limited ability to specialize their studies.[6] Twenty survey respondents indicated that they specialized their IST education. While not collected in the survey; presumably, these students felt some motivation to schedule the additional course work. The specific motivations are probably as diverse as the respondents; however, two seem reasonable: personal interest and anticipation of future need. In either case, students expended personal resources—time in this case—to acquire additional learning. Table 13 summarized the effect of these specializations on assessments of education topic interest and perceived topic value.

[6] The default curriculum used in this study allows for two electives. To select additional courses, students must validate default courses, or over-schedule courses. The IST curriculum is presently being redesigned to incorporate course "tracks." These tracks will provide students with greater opportunities to focus studies in specific topic areas.

Effects of Education Specialization on Education Topic Interest and Value *	
Effects on Topic Interest	When respondents design study based upon particular topics, they rated their interest in those topics one point higher than other topics. Respondents have a seventy-seven percent chance of reporting high interest (ratings five, six, or seven points) in topics that they reported as specialized study.
Effects on Topic Value	When respondents designed study based upon particular topics, they rated the value of those topics one point higher than other topics. Respondents have an eighty-two percent chance of reporting high interest (ratings five, six, or seven points) in topics that they reported as specialized study.
* Data from twenty survey responses that reported one or more education topic specialization beyond the default IST curriculum. Ratings based on a seven-point scale.	

Table 13. Significance of Education Specialization

The data supporting Table 13 indicates that decisions to invest in additional education are based, in part, on a students' interest in the education topic. More significantly, it reveals that specialization usually predicts high valuation of the education topic. This is consistent with the previous analysis of interest and value, where high respondent interest assessments usually predicted high value assessments.

E. SOCIAL IMPACT OF RESIDENT EDUCATION

Many Marine Corps officers pursue graduate level education. These education endeavors range from member-funded part-time study, to Marine Corps supported off-duty education, or to full-time fully-funded advance degree providing education like the SEP. As mentioned previously, the NPS provides most of the Marine Corps' SEP education, and the NPS IST curriculum is the sole source of 9648 MOS qualifications.

One of the unique characteristics of the NPS education is its corporate environment. The school is dedicated to educating military officers. The school responds to the needs of the Department of Defense in terms of enrolment, curriculum, and research. This results in an academic environment where students and staff share a common desire to advance the national security posture of the United States. Presumably, a valuable byproduct of graduate education in this setting is an increased social

connection among defense professionals. This section analyzes the extent that social relationships developed at NPS contribute to post-education performance.

1. Value of Naval Postgraduate School Relationships

Graduates of the NPS IST curriculum indicate that social relationships developed at the NPS are important to their subsequent assignments. Figure 20 plots the average respondent rating for various elements of their NPS experience. Using a rating scale that ranged from one (not critical) to seven (critical), respondents rated how significant NPS acquired knowledge, skills, peer relationships, and NPS staff relations were to their subsequent billet responsibilities.

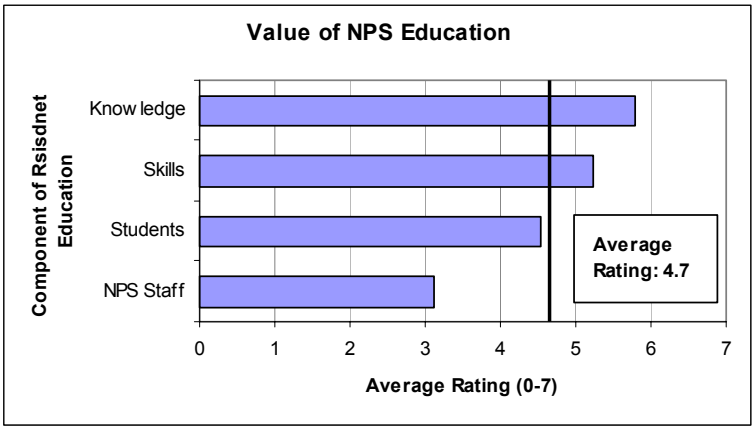

Figure 20. Average Respondent Rating of Significance of NPS Experience

As shown in previous sections, the figure shows that knowledge and skills developed at NPS are quite significant. This should come as no surprise, as the explicit objective of NPS is to provide students with pertinent knowledge and skills in information technology. These high ratings confirm that NPS is meeting its educational objectives. What may not be as intuitive is the significance that respondents placed on the social relationships advanced during NPS education. The data supporting Figure 20 indicates that respondents ascribed reasonably high value to the formulation of social relationships among student peers. Somewhat less significant is the value of relationships with members of the NPS staff.

This may be explained by the social setting at NPS. Students progress through the two-year curriculum by section. Sections are formed from students in like curriculums who start their education at the same time. Therefore, most students move through the

curriculum with a common group of about thirty to fifty peers. Students' relationships with NPS staff members should naturally be less mature because most staff members are exposed to students with a much lower frequency than students within their peer group. However, this data suggest that social relationships are influential. Furthermore, it indicates that different education methods, such as various distant learning programs, may fall short of achieving the full potential of the resident programs if these social issues are not considered.

2. Probability of Using Social Relationships

Another way to estimate the value of social relationships is to determine the frequency that they are used. Figure 21 plots the average probability that the thirty-two respondents would use the knowledge, skills, and social relationships developed at NPS in a given week. A comparison between Figure 20 and Figure 21 reveals that the probability of use is aligned with the value of the education component. In fact, the correlation between value and probability of use is 0.99.

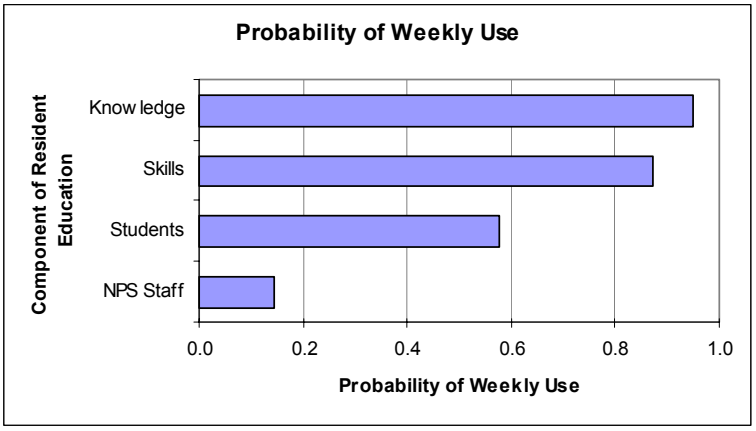

Figure 21. Weekly Probability of Respondent Use of Education

The probability of calling on social contacts developed at NPS, especially student-peer relationships, is a further indication that social relationships emerging from NPS education provide value to the Marine Corps. It helps to quantify the value of social relationships by demonstrating the frequency that these relationships are employed in post-education billets. From Figure 21, there is about a sixty percent chance that an IST graduate will contact a fellow IST student in a given week. Furthermore, from Figure 20, the value of that contact is about four and a half on a seven-point scale.

The substantial difference in the probabilities of contacting a fellow student and a NPS staff member, less than a third as likely, can also be explained. As highlighted in the previous section, it is reasonable to assume that graduates have a greater number of social relationships with fellow students compared to NPS staff. Furthermore, the larger number of student-peer relationships cross a diverse range of educational topics. Whereas the less common NPS staff relationships would be expected along more narrowly defined topics. Therefore, the weekly probability of contacting a NPS staff member should naturally be less than the probability of contacting one of the many student-peers. This is compounded by the fact that many graduates work in the same commands or in common geographic regions.

F. SUMMARY OF ANALYSIS

The analysis performed on the subjective data of survey respondents lead to several observations.

- The composition of the IST curriculum is appropriate to meet the Marine Corps' graduate level information technology education requirements. However, it appears that slight modification to the curriculum (some of which are currently underway) could better align the curriculum to the requirements.
- Officers selected to study the IST curriculum have the potential to use their education to advance the Marine Corps in areas other than their 9648 MOS positions. Thesis efforts can provide direct value to the service while meeting the educational objective of the thesis process. Additionally, the IST education is used and presumably provides value in any billet assignment.
- There appears to be a relationship between students' interest in particular topics and assessments of value in those topics. This has implications in the methods that education quotas are provisioned and how curriculums are administered.
- Social relationships developed during resident education provide subsequent value to the organization. While not the primary objective of the education, this facet of the resident education experience should be acknowledged when comparing resident and non-resident education delivery methods.

IV. MEASURING THE RETURN ON EDUCATION

It is not possible to measure the exact monetary value of graduate education to the Maine Corps. However, this chapter describes a theory and method to estimate the relative return on educational investment using process output as a surrogate for value, or a numerator, with the cost to produce those outputs as a denominator to form a ratio. The method is applied using actual data as a proof of concept of how to generate relatively objective estimates of return on graduate education.

A. THEORY

As indicated in this paper's literature review, there are many approaches to measuring the value of education. Regardless of the approach, common units of value must be identified in order to collect data and make meaningful comparisons. At a national level, these analyzes have compared gross domestic product to average education levels. In corporate settings, stock price has been compared to company costs associated with employee learning. To analyze local training value, training costs have been compared to estimations of improved job performance. And in non-profit organizations, promotion rates have been compared to education levels.

Most of these studies focused on education as a way to ensure a given set of capabilities. While the focus on capabilities provided insights on the value of education, these studies failed to show how education affects subsequent productivity in an organization, based on actual exercise of those capabilities, presumably provided by the education.

One way to estimate the value of education in practice would be to measure both the amount of knowledge used in organizational processes to produce given outputs and the cost to use this knowledge. Establishing common units of knowledge and a relationship of knowledge to value would resolve the question of how much value the NPS IST education provided its students.

1. Knowledge Value Added

A method called Knowledge Value Added or KVA (Housel and Bell 2001) is used in this chapter to estimate more objectively the relationship between knowledge and

value in sample processes. The KVA method reveals how knowledge is actually used at a process level in the organization. An organizational perspective is achieved by aggregating the knowledge contributions within the specific organizational processes. The KVA model and its underlying assumption are presented in Figure 22.

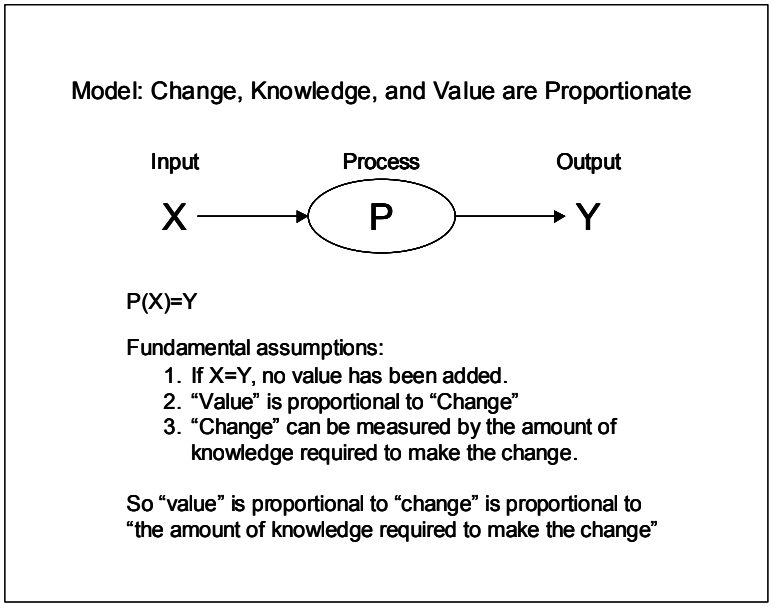

Figure 22. Fundamental Assumptions of Knowledge Value Added (From: Housel and Bell, 2001)

Using the KVA approach to measure the knowledge embedded in processes requires that common units be established to measure knowledge across diverse processes. The costs attributed to each process must also be determined in standard units.

The validity of the KVA method is based on its fundamental assumptions—any change between an input and an process output must be proportional to the value derived from the process. As for reliability, the results of the KVA method are as reliable as the estimations of the measured processes. Therefore, the KVA method is able to increase reliability by increasing the fidelity of process description and execution.

The KVA method of measuring knowledge differs from other approaches. In KVA, knowledge is identified in terms of processes. Other approaches represent knowledge as capabilities waiting to be used. While this is a useful view of knowledge in some circumstances, it makes it difficult to determine how the knowledge is actually used

and how the usage compares across different processes. This knowledge usage and comparison is what the KVA method provides.

2. Measuring Knowledge Embedded in Processes

The crux of KVA is describing an organizational process in a way that represents the knowledge required to perform the process. This description must also be applicable to any process to allow objective comparisons between organizational processes. To measure the knowledge required to perform a process, the process must be described in terms of the changes that result from the use of knowledge. There are many ways to perform this description (Housel and Bell, 2001); three are explained here.

First, a process can be described by calculating the amount of time it takes to educate someone to successfully perform the process. This requires an assumption about the person being educated, a high school graduate, for example. Gathering this data usually involves interviewing people experienced in the process. From these, process and sub-process descriptions are recorded along with the assessments of the learning time required to prepare someone to perform the process. Using learning time as a surrogate for knowledge provides an objective means to compare dissimilar processes.

A second method to capture the knowledge embedded in a process is to describe the process in terms of instructions. Similar to the previous approach, this method records the number of instructions required to accomplish a particular process; processes that are more complicated have more instructions and thus more embedded knowledge. While it depends on the process, collecting this data usually involves interviewing people skilled in the process. With number of instructions as a common unit, comparisons across processes are possible.

A third approach extends from the last and entails describing processes as a series of yes/no questions. This binary query method captures process knowledge by calculating the number of yes/no questions required to successfully perform the process (Pickering 1995). It reduces the process to a quantity of bits. An analogy for this approach is the digital encoding of a photographic image. A large or high-resolution image requires more bits to encode than a smaller, low-resolution image. The analogy continues; the better the image, the more bits, and the more knowledge. Binary query provides a way to measure

knowledge that spans process—any process can be described using this approach. However, the actual application of this approach is involved and should be balanced against the objectives of the subsequent calculations.

3. Measuring Process Cost

Cost determination is required to complete the value-cost ratios. Capturing process cost involves isolating the revenues allocated to accomplish particular processes. It is important to use consistent process description while collecting knowledge and cost data. There are a number of ways to gather cost data. Most organizations have a method to allocate costs across their business units. This cost data can be allocated to the process level by interviewing managers familiar with the processes.

Armed with the amount of knowledge, in standard units, embedded in a process, and the process costs, a ratio between cost and value can be created to compare different processes in common units.

B. METHOD

The operationalism of the KVA method, to support this research, is described in this section. This proof of concept involved subjects who completed the Naval Postgraduate School (NPS) Information System Technology (IST) curriculum and relates to processes that formed their post-education jobs. Data was collected via a series of telephone interviews; data collection for the principal processes associated with a specific job was completed in less than one hour. The specific implementation of the KVA theory follows.

1. Process Identification

The identification of processes begins with a subject's job description. In this study, three or four processes were described for each information technology job actually held by the subjects. For each of the job processes, subjects provided a breakdown of the percent of their time they spent on each process during the course of a typical year. These percentages were converted into days and labeled as an occurrence; see Table 14.

2. Value Measurement

Knowledge or value was measured by estimating the relative learning time required to prepare a person to perform one of the identified processes (the first of the three process description methods explained in the previous section). The subjects were asked to assume that the person receiving the learning had no specific technical education but did understand the organization: a Marine officer of similar grade and experience but with no specialized technical education. The learning times were normalized to one hundred units to standardize subsequent comparisons. These one hundred units of learning time were distributed across the identified processes for each job. Additionally, subjects were asked to ordinally rank the processes by learning difficultly. This served as a check of the learning time, based on the assumption that difficult processes require more preparation time than simpler processes.

Processes	**Occurrence**	**Relative Learning Time**	**Learning Difficulty**	Acquisition and Program Management	Computer Networking	Computer and Network Security	Database	Economic and Financial Management	Managing Change	Professional Military Education	Software Engineering	Software Language Programming
Software Project Manager						Learning Allocation by Process						
Software requirements	72	45	1		20%	30%					40%	10%
Acquisition management	120	40	2	40%				30%	10%	20%		
Database construction	24	10	3				90%					10%
Software configuration release	24	5	4	30%		10%		20%			40%	

Units of Knowledge Embedded in Each Process										TOTAL
Software requirements	0	648	972	0	0	0	0	1296	324	3240
Acquisition management	1920	0	0	0	1440	480	960	0	0	4800
Database construction	0	0	0	216	0	0	0	0	24	240
Software configuration release	36	0	12	0	24	0	0	48	0	120
Software Project Manager (Total for Job)	1956	648	984	216	1464	480	960	1344	348	8400

Table 14. Knowledge Value Calculations

To attain an additional level of detail, subjects were asked to allocate learning time across the education topics of the IST curriculum, within each process. With this

data, the knowledge associated with each process was calculated by each education topic. Table 14 shows one example for a Software Project Manager. The top half of the table consists of data recorded during the interview. The bottom half shows the results of the calculations performed on the collected data.

In this example, the job of Software Project Manger consisted of four main processes: Software requirements, Acquisition management, Database construction, and Software configuration release. The number of days each year that the subject performs each process is recorded under the Occurrence field. The Relative Learning Time reveals the relative complexity of each process that the subject assessed for each; these learning times sum to one hundred units for all processes. The ordinal ranking of process difficulty, where one represents the most difficult process to learn, validates these values. The data collection concluded with the subject's assessment of how learning should be allocated across topics within each process. These values are shown as percentages in the top half of the table, and they sum to one hundred percent for each process.

Using the collected data from the top half of the table, the estimated number of knowledge units is calculated for each process. The calculations consist of multiplying the occurrence frequency by the relative learning time by the percent allocation for each topic. The resultant value is assigned to the same topic and process. To illustrate, units of Computer Networking knowledge embedded in the Software Requirements process is given by multiplying (72) by (45) by (20%) to yield 648. After completing these calculations for each topic-process pair, the knowledge units are summed by education topic and by process.

These computations show the relative quantity of knowledge, allocated by topic, associated with each process. For example, Acquisition Management is the highest knowledge process despite being the second hardest process to learn. This is because Acquisition Management is a process that is conducted more frequently. Not surprisingly, Acquisition and Program Management is the education topic with the largest number of knowledge units.

3. Cost Measurement

Cost is computed by capturing the salary cost for the person who performs the particular job, i.e., uses the knowledge to produce outputs of given processes. This salary cost can then be assigned to processes and sub-processes based on the percentage of time that the person engages in those activities. Furthermore, costs can be segmented according to the education topics that are required to perform the processes and sub-processes. Table 15 continues the previous example and demonstrates the method used to collect and calculate costs.

Processes	Occurrence	Cost	Acquisition and Program Management	Computer Networking	Computer and Network Security	Database	Economic and Financial Management	Managing Change	Professional Military Education	Software Engineering	Software Language Programming	
Software Project Manager		$ 243.81/ Day	Breakdown of Topic Use within each Process									
Software requirements	72	$ 17,280		10%	30%					30%	30%	
Acquisition management	120	$ 28,800	66%						20%	14%		
Database construction	24	$ 5760				100%						
Software configuration	24	$ 5760			10%		30%	25%	5%	30%		
Costs Associated with each Process												TOTAL
Software requirements				$ 1728	$5184					$ 5184	$5184	$17,280
Acquisition management			$19,008						$ 5760	$4032		$28,800
Database construction						$ 5760						$ 5,760
Software configuration release					$ 576		$ 1728	$1440	$ 288	$ 1728		$ 5,760
Software Project Manager (Total for Job)			$19,008	$ 1,728	$ 5,760	$ 5,760	$ 1,728	$ 1,440	$ 6,048	$10,944	$ 5,184	$57,600

Table 15. Sample Process Cost Calculations

The data in the top half of Table 15 was gathered from the subject during the interview. It consists of the same processes and occurrence rates described in the previous table. Within each of these processes, the subject provided an assessment of how much his knowledge of the education topics was actually used during the execution of the processes. This is recorded as the percentage values in the top half of the table. Lastly, a daily salary rate was calculated based on the rank and experience of the subject.

The collected data is used to calculate the costs related to performing the various processes. The yearly cost of each process is computed by multiplying the occurrence rate by the daily salary rate. The sum of these costs equals the subject's total yearly salary. The costs associated with each topic and process is calculated by multiplying the yearly cost of the process by the percentage of time that each topic was used. Lastly, the costs are summed by topic and by process.

4. Comparisons

With every processes described in common units of knowledge and ascribed costs based on the use of the knowledge, value comparisons can be performed between topics, processes, and even between subjects. To demonstrate some of the possible comparisons, Table 16 lists the value ratios from the three subjects examined in this study. While comparisons could be performed at the process level, Table 16 provides only the aggregation of multiple processes in the form of three different jobs.

The table displays value in two forms: return on knowledge and cost per unit of knowledge. The return on knowledge percentage is derived from dividing job output (knowledge) by cost. A hurdle rate—return on knowledge rate for the job—for each job is also computed from the total knowledge divided by the total job cost. From this information, many types of comparisons are possible.

Before presenting example comparisons, it is important to caveat the fidelity of these sample calculations. Wide ranging conclusions should not be drawn from these particular calculations due to the small and limited sampling used to support them. However, these calculations do support rough-cut estimations and reveal order of magnitude relationships that may not be otherwise obvious. Moreover, the time costs associated with preparing this information is about an hour per job.

The ratios in Table 16 reveal several interesting relationships. Starting with the hurdle rates, it is evident that some education topics achieve higher returns than others. In this case, the Managing Change and Professional Military Education topics surpass the hurdle rate for all three job descriptions. This suggests that these topics are frequently employed in these jobs. Conversely, several topics fail to reach the hurdle rate in any of the jobs, which suggests that they are used infrequently. These comparisons are helpful to

identify trends in education topics across multiple jobs and processes, because the jobs and processes are described in common units.

		Acquisition and Program Management	Command and Control	Communication System Engineering	Computer Networking	Computer and Network Security	Database	Economic and Financial Management	Managing Change	Professional Military Education	Software Engineering	Software Language Programming
Output/Cost	Hurdle Rate											
Software Project Manager	**14.6%**	10.3%			37.5%	17.1%	3.8%	84.7%	33.3%	15.9%	12.3%	6.7%
Executive Officer	**12.7%**	49.4%				3.1%		1.6%	19.4%	14.4%	6.1%	
Develop Digital Massage Standards	**14.7%**	18.4%	8.1%	8.1%	8.5%				18.3%	16.2%		
Cost/Unit of Knowledge												
Software Project Manager		$ 9.72			$ 2.67	$ 5.85	$ 26.67	$ 1.18	$ 3.00	$ 6.30	$ 8.14	$ 14.90
Executive Officer		$ 2.02				$ 32.00		$ 64.00	$ 5.14	$ 6.95	$16.53	
Develop Digital Massage Standards		$ 5.44	$12.36	$ 12.36	$ 11.74				$ 5.46	$ 6.18		

Table 16. Cost-Knowledge Ratios

These ratios can also highlight inconsistencies between jobs and processes. As an example, the cost per unit of Economic and Financial Management knowledge between the Software Project Manager and the Executive Officer jobs differ by much more than an order of magnitude. While some of this difference likely stems from the inaccuracies of the data sampling, such a large difference suggests that the Software Project Manager uses his knowledge in this topic much more frequently than the Executive Office, which drives down the unit cost of the knowledge.

A final type of comparison, not demonstrated in this example, can be performed for different people performing the same processes. Once the knowledge embedded in a process is estimated, the only way to change the value ratio is by altering the costs required to perform the process. This can be witnessed in two ways: change the employee costs associated with the process and/or change the frequency that the process is completed.

This effect can be shown by a simple example. For a process such as sweeping the floor, there is an established amount of knowledge required. Regardless who performs the task, the same amount of knowledge is expended. This is the fundamental premise. However, in order to identify the most effective sweeper, sweeper cost and speed must be considered. For example, if Sweeper A gets paid twice as much as Sweeper B (presumable due to a greater knowledge capability) but sweeps three times faster than Sweeper B, then Sweeper A has a lower cost per knowledge use.

This is a fundamental distinction of the KVA method. It separates KVA from other knowledge valuation models such as Phillips' return on investment process for training. Most processes compare the costs of knowledge acquisition or capability to a subjective estimation of value that results from the acquired knowledge. In KVA, the knowledge acquisition costs are only relevant to the extent that they influence the salary cost of the employee. Knowledge value added computations focus on representing processes in common units and allocating a cost for the completion of each process.

V. DISCUSSION

A. RESEARCH QUESTION SUMMARY AND IMPLICATIONS

The results of this study are best described by answering each of the specific research questions.

1. Meeting Requirements

How well does the Naval Postgraduate School (NPS) Information System Technology (IST) curriculum meet Marine Corps graduate level Information Technology (IT) education requirements? Analysis indicates that the IST curriculum satisfactorily meets the Marine Corps' graduate level IT education requirements. Figure 8 and Figure 10 show that the majority of the Marine Corps' education requirements, described by Billet Education Evaluation Certificates (BEEC) and graduate responses, are included in the IST curriculum.

Moreover, Figure 9 and Figure 11 compare the relative weight of requirements to the curriculum emphasis of topics to show that the time devoted to most topics is well balanced and evolving to meet requirements. The evolutionary nature of the IST curriculum content indicates that the NPS is proactively engaged in providing education to meet the changing information technology environment in the Department of Defense.

2. Curriculum Value

What is the value of the IST education to the Marine Corps? This study provides several indications that the IST education provides significant value to the Marine Corps. First, the education meets the sponsor's requirements, which presumably indicates that results of the education are worth their costs. Second, IST curriculum enrollment of Marine officers has grown over the past ten years. Invariably, one source of this increase is the growing importance of information technology within the service. However, the specific decision to send additional officers to participate in the IST curriculum is a strong sign of Maine Corps satisfaction and perceived return on investment from the program.

Lastly, Marine graduates with this education indicate that they are able to successfully influence Marine Corps processes as a result of their IST education. Using a

seven-point scale to assess value (one=low, seven=high), graduates responded that the average value of the IST curriculum, across all topics, was 4.4 in IT billets and 4.0 in all other billets. These ratings indicate relatively high curriculum value and are reinforced by the data in Figure 14 and Figure 15. These figures show graduates' assessment of the value of knowledge (mean=5.8) and skills (mean=5.2) acquired at NPS. Furthermore, Figure 16 reveals that over sixty percent of survey respondents say that they use their NPS acquired knowledge *and* skill on a daily basis. These findings suggest, quite dramatically, that graduates of the IST curriculum believe that their NPS education increases their ability to positively influence the Marine Corps.

3. Curriculum Impact on Productivity

How does the NPS IST curriculum improve productivity within Marine Corps SEP billets? This study identified several ways that the IST education improves productivity in the Marine Corps. These improvements take form in the individual actions of Marines who completed the education, as well as, from tools produced by these Marines, that in turn improve the productivity of Marines throughout the Corps.

The most common way that the IST education improves productivity in the Marine Corps is by allowing graduates to "hit the ground running" when they enter their information technology billets. They report that they are knowledgeable and skilled in technical issues relating to their responsibilities. While most survey respondents felt that their education helped them transition into IT billets, several also highlighted the ability to make better decisions as a result of their education. Additionally, relationships developed with classmates and NPS staff members appear to increase productivity in many cases.

The thesis research performed by IST students can also improve productivity. In one case, a scheduling tool was developed and fielded to Marine Corps recruiters. It is estimated that the tool saved each recruiter sixty hours a year. In several other cases, students were able to perform various studies and analyses that would have otherwise been completed by a Marine not in a student status.

What these productivity improvements have in common is that the Marine Corps can reap greater benefits from its IST officer students by ensuring that they remained focused on solving Marine Corps problems.

4. Personal Desires and Value

What effect do personal desires have on education value? This research has shown some positive correlation between personal education desires and assessments of education value. This suggests that greater organizational value will be realized when students are provided options to fulfill their personal education aspirations. There are two areas where this is relevant.

The first time that personal and service educational objectives come into potential conflict is during the Marine Corps screening and selection of Special Education Program (SEP) officers. Applicants list their curriculum choices by priority. However, the "needs of the Corps" often take precedence over individual desires. While these *needs* must be met and everyone is not likely to get their first choice, understanding the potential payoff of attaining assignment satisfaction is worthwhile. The current curriculum assignment process is so focused on meeting the Corps' needs that less popular curriculums are filled by the first suitable applicant, regardless of applicant desires (Esparza 2002b).

The second time that students have the option to tailor their education is during the execution of the curriculum. In the case on the IST curriculum, the default course list is evolving. Where previously, students where given only two course electives; the curriculum is beginning to institute topic "tracks" that allow students to select one of several three-course series. These tracks provide for specialization beyond the default curriculum, which still meets all sponsor requirements, but fall short of the time and study required for a dual degree.

Some may argue that this small amount of specialization is not worth the additional study time, especially if the base courses meet sponsor expectations. However, this study suggests that the extra two or three courses that constitute the track may be worth the extra curriculum time. First, the research presented in this paper indicates that student-selected tracking results in higher perceived value. Additionally, the educational

focus provided by a course track is likely to align with thesis research, which should benefit form the additional depth of study.

5. Social Relationships and Value

Is there a relationship between social connections formed during graduate education and subsequent productivity? This research indicates that social relationships are established and maintained because of resident education. The value of these relationships is found during subsequent billet responsibilities. This was most dramatically demonstrated in Figure 20 where the average value of an NPS relationship was 4.5 (on a zero to seven point scale) and Figure 21 where the average probability of calling on that relationship during a given week was fifty-eight percent.

Clearly, these social aspects of education are less important than the knowledge and skills developed at the NPS. However, these relationships are a byproduct of the current process, and this study shows that they do contribute substantially to subsequent efforts. Understanding how certain social connections provide value is important to increasing the potential of education provided in the current resident process, as well as, to designing distant education approaches that appreciate and foster student relationships.

6. Measuring the Value of Education

Can a Knowledge Value Added (KVA) method be used to assess the current value of graduate education? The KVA method can be used to measure and compare the value of education. The approach used in this study was able to reveal the relative contributions of different education topics to different processes within the examined jobs. The results of the proof of concept, explained in Chapter Four, suggests that a similar KVA method could be used in the SEP to make decisions that are more informed.

In an organizational context, education produces capabilities. Most studies of educational value within organizations focus on describing and estimating the value of these capabilities. With the exception of the Phillips' Return on Investment approach, most fail to show how the capabilities are used in the organization. The KVA method steps beyond Phillips' by providing a method to show and compare education use in common units.

The ability to see education (capability) in use is a central theme of the KVA method. A capability that is not used remains merely an option. However, when the option is exercised to provide some productivity, it yields value, which can be measured and assessed using a KVA method (Housel 2002).

B. RECOMMENDATIONS

The benefit of this research can be viewed as contributing to three domains: the Marine Corps, the Naval Postgraduate School, and the application of KVA to measure education.

1. Consumers

In the context of this research, the United States Marine Corps are the consumers of graduate level education. The SEP in the Marine Corps' program designed to manage the service's graduate education investments. In general, the SEP fulfills the mandates of its charter: requirements are adequately identified and provisioned. However, close examination of the program reveals potential opportunities to improve the overall performance of the program to meet organizational needs.

a. Advocacy

The operational and supporting commands of the Marine Corps fail to leverage the educational and research opportunities provided by students attending the NPS. Every Marine student assigned to the NPS has several years of experience in one of the Marine Corps' primary occupational specialties. However, once assigned to NPS, the connection between the student and his occupational community is effectively severed. In general, only student initiated actions cause the connection to continue.

The result of this condition is a lost opportunity. Instead of building upon their experience and knowledge to study issues important to their respective communities, many students immerse themselves in the academic pursuit of knowledge with no particular plan to apply that knowledge to a Marine Corps subject.

It appears that this condition may results from low density of NPS graduates in the Marine Corps. Without a personal knowledge of the NPS, there is a hesitancy to engage what is otherwise a foreign institution.

To begin countering this misperception, a broker is required to communicate the issues that are important to the Marine Corps and the topics that are part of the various NPS curricula. There are several places to look for these brokers. On the NPS side, all Marine staff and students should seek to remain engaged in Marine Corps issues. There are examples in other curriculums where Marine instructors fulfill this function. However, the IST curriculum has no Marine instructors. Furthermore, the IST curriculum has the highest density of Marine students.

Outside of specific curriculums, a broker could be assigned to the School's Executive Director of Institutional Advancement to formally voice Marine Corps concerns throughout the School. One of the tasks of this office is to ensure that the NPS lives up to its claim of Corporate University for the Navy and Marine Corps.

On the Marine Corps side, occupation field managers, community advocates, and commands assigned SEP officers are in suitable positions to voice educational and research concerns. These Marines often face challenges that they are unable to devote adequate resources towards solving. These challenges are exactly the types of projects and research that the student-officers at NPS could use their experience and education to solve, at no additional cost to the service. Furthermore, in the process of analyzing these problems, the student prepares himself for return to a Marine Corps command where he is better able to make a fast transition towards improving productivity.

b. Requirements

The current process of using BEEC to describe graduate education requirements is flawed. There are two reasons why the products of this type of requirement process inaccurately represent the Marine Corps' graduate education requirements. First, officers with the designated education are not necessarily assigned to the billets certified as requiring the education. Secondly, data provided in the BEEC is too subjective to enable objective decisions to be made concerning the allocation of educational resource.

Taking steps to solve these problems need not require a complete revision of SEP management processes. However, if the Marine Corps seeks to improve the

performance of it educational investments, some changes are warranted. Currently, NPS graduates are assigned to commands that rate officers with various NPS degrees, based upon a validated BEEC. In practice, many graduates never actually serve in the billet described by the BEEC. In these cases, the BEEC serves only as an administrative hurdle to gaining a SEP officer. However, this condition is not always bad. It provides the command leadership flexibility to respond to current situations. This flexibility would be removed if SEP officers were rigidly assigned to BEEC-approved positions.

While there are positive and negative aspects of the current practice of assigning SEP officer, the current practice is not consistent with the intention of the SEP policy on billet education certification. Perhaps a more realistic method to assign SEP officers, and retain local command flexibility, would be to assign NPS graduates to commands as opposed to billets. This action would align the policy with the current practice. The resultant requirements process would cause command to describe their aggregate graduate education requirements for competition between other commands.

Unfortunately, this new requirement process would remain as subjective as the current BEEC process. Therefore, to improve the efficiency and efficacy of service investments in graduate education, a more objective method of identifying educational requirements is warranted. This research has advanced one such method, the KVA method. While the KVA method may not be the specific approach used to solve this problem, without adjusting the process to increase the objectivity, assessments of program performance will remain subjective.

2. Providers

In the context of this research, the Naval Postgraduate School serves as the graduate education provider. Beyond the observation that the NPS IST curriculum fulfills the sponsor requirements, this research highlights two areas of curriculum management that should not be overlooked. The results of this thesis suggest that there are important curriculum design and feedback monitoring decisions that are influential to improving the performance of graduating officers.

Analysis in this study concluded that social relationships developed during resident NPS education and curriculum latitude to satisfy personal educational desires

provide downstream value. Two implications for curriculum designers emerge from these conclusions. The first issue relates to efforts to provide graduate education in non-resident formats. While the objective of non-resident or distant learning education is to provide education at a quality similar to the resident experience, this research indicates that this objective will not be attained without accounting for the social interactions of staff and students.

A second issue, curriculum design consideration relates to meeting the educational desires of the student as well and the curriculum sponsors. The ongoing efforts by the NPS Department of Information Sciences to provide curriculum tracking seems to be an appropriate approach to achieving this balance.

This research also advanced an approach to improve curriculum feedback beyond the current Education Skill Requirement process. One advantage of the KVA method of measuring knowledge is its ability to show performance changes. Because KVA uses a fixed description of a process, any changes that increase (or decrease) overall process performances are attributable to the person performing the process. Therefore, it the person performing the process increases their knowledge or skills, process performance will also increase and be captured during the KVA computations. Furthermore, educational changes can be compared across jobs and processes because KVA describes all jobs and processes in common units.

3. Feedback

This study described and demonstrated a method to estimate the value of education in the context of the Marine officers who have been educated in the IST curriculum of the NPS. The proof of concept revealed one way in which KVA could be used to determine and compare the value of education. However, the method demonstrated in this proof of concept is not limited to the context of this paper. Hopefully, this proof of concept has revealed the potential value of the KVA method in different situations.

The KVA approach does not try to calculate the knowledge capability in an organization by looking at the employees. It determines the quantity of organizational knowledge by examining the changes that the knowledge produces in organizational

processes. These changes in output are represented by the knowledge required to make them. This model is more in keeping with the information age notion that knowledge is proportionate to value, as opposed to industrial age thinking where the specific knowledge capabilities required by the organization are acquired and released based on the changing demands of the organization. This paradigm suggests that the half-life of knowledge is tied to changes in process design.

The information age approach to knowledge suggests that the half-life of knowledge depends on its use (Cook 2002b). In this paradigm, the value of knowledge actually increases with use because the user employs the knowledge faster and to better advantage. In this sense, knowledge is not a scarce resource. Furthermore, knowledge creation actually takes place during use. As situations change, knowledge is adapted to meet new requirements and new learning build upon previous knowledge. The KVA method is able to capture this feedback loop because expanded knowledge allows the user to complete processes quicker or more often.

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APPENDIX A. BILLET EDUCATION EVALUATION CERTIFICATE

BILLET EDUCATION EVALUATION CERTIFICATE (1500)
NAVMC11345 (5-97) Ref: MCO P5311.1C
SN: 0109-LF-069-0100

Complete a separate Certificate for EACH billet

T/O NUMBER	T/O LINE NUMBER	BILLET TITLE/ORGANIZATION LOCATION		
GRADE	MOS	REQUIRED BY F/Y	OSD/JCS POSITION DESCRIPTION NO.	

CURRICULUM SHOULD INCLUDE (List comprehensive area and/or electives required for this billet)

JUSTIFICATION (Simple, brief narrative explaining why the occupant of this billet requires the special education described. What does he do with the knowledge? How does he employ it?)

SPECIAL EDUCATION DISCIPLINE (Select the course of instruction and alternate to be attended which best fits the exact requirements of the billet.)	RECOMMENDED LENGTH (*years*)
RECOMMENDED INSTITUTION AND LOCATION (Select school and location best suited for the exact requirements of this billet. List alternate institution, if applicable.)	EDUCATION PREREQUISITE (MCO 1500.5) ❑ NECESSARY ❑ DESIRABLE

SIGNATURE OF ADVOCATE or OCCFLD Manager/CODE/DATE	SIGNATURE OF MOS Specialist/CODE/DATE

CG MCCDC DECISION

APPROVED: DATE	DISAPPROVED: DATE

FOOTNOTE:

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APPENDIX B. DEFAULT MARINE INFORMATION SYSTEM TECHNOLOGY COURSE LIST

1st QTR Fall/Spr	Visual Basic *IS-2020*	Computer Arch & Operating Systems *CS-3030*	Statistics for Technical Management *OS-3105*	Strategy & Policy *NW-3230*	
2nd QTR Win/Sum	Software Design *IS-3020*	Database *IS-3201*	Computer Networks *IS-3502*	Ops Research for Computer Systems *OS-3004*	
3rd QTR Fall/Spr	Introduction to C4I *CC-3000*	Decision Support Systems *IS-3301*	Principles of Information Operations *IW-3101*	Math for Info Systems Security Officer *MO-1901*	
4th QTR Win/Sum	Intro to Comm System Engineering I *EO-2514*	Space Technology Applications *SS-3011*	Introduction to Computer Security *CS-3600*	C4ISR System Evaluation *IS-3172*	Managing Planned Change in Complex Org *MN-4125*
5th QTR Fall/Spr	Intro to Comm Systems Engineering II *EO-3514*	Software Engineering & Management *IS-4300*	Information Systems Evaluation *IS-4031*	Military Satellite Communications *SS-3613*	Introduction to Thesis Research *IS-3333*
6th QTR Win/Sum	Communication System Analysis *EO-4514*	Thesis Research *IS-0810*	Architecting Information Systems *IS-4220*	Elective	
7th QTR Fall/Spr	Thesis Research *IS-0810*	Financial Mgt in the Armed Forces *MN-3154*	C4ISR Systems *CC-4221*	Principles of Acquisition Management *MN-3331*	
8th QTR Win/Sum	Thesis Research *IS-0810*	Information Systems Management *IS-4182*	Thesis Research *IS-0810*	Elective	

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APPENDIX C. MARINE CORPS INFORMATION TECHNOLOGY BILLETS (AFTER: KLINGER 2002B)

Billet Title	Command	Rank	Owner
D215/040DISN JT PROJ OFF	DISN JOINT SYSTEMS OFCR	CAPT	PP&O
DATA COMMUNICATIONS OFF	DFAS/SABRS KANSAS CITY	MAJ	P&R
DATA COMMUNICATIONS OFF	DFAS/SABRS KANSAS CITY	MAJ	P&R
DATA COMMUNICATION OFF	DFAS/SABRS KANSAS CITY	CAPT	P&R
DATA COMMUNICATION OFF	DFAS/SABRS KANSAS CITY	CAPT	P&R
DATA COMMUNICATIONS OFF	DFAS/SABRS KANSAS CITY	CAPT	P&R
631/06 C4S STAFF OFFICER	HQ US TRANSPORT CMD JT	MAJ	PP&O
663/03 DATABASE ENGINEER	HQ US TRANSPORT CMD JT	MAJ	PP&O
DIR INFO TECH	MARCORSYSCOM QUANTICO VA	LTCOL	MCSC
INFO TECH OFFICER	MARCORSYSCOM QUANTICO VA	MAJ	MCSC
DATA SYSTEMS MGR	MARCORSYSCOM QUANTICO VA	CAPT	MCSC
MGMT DATA SYS OFFICER	MARCORSYSCOM QUANTICO VA	LTCOL	MCSC
MGMT DATA SYS OFFICER	MARCORSYSCOM QUANTICO VA	CAPT	MCSC
APML	MARCORSYSCOM QUANTICO VA	MAJ	MCSC
MGMT DATA SYS OFC	MARCORSYSCOM QUANTICO VA	CAPT	MCSC
MGMT DATA SYS OFC	MARCORSYSCOM QUANTICO VA	CAPT	MCSC
APM IS	MARCORSYSCOM QUANTICO VA	MAJ	MCSC
SYSTEMS ANALYST	MARCORSYSCOM QUANTICO VA	MAJ	MCSC
SYSTEMS ANALYST	MARCORSYSCOM QUANTICO VA	MAJ	MCSC
HEAD MISB	MARCORSYSCOM QUANTICO VA	MAJ	MCSC
SYSTEM ANALYST	MARCORSYSCOM QUANTICO VA	MAJ	MCSC
SYSTEM ANALYST	MARCORSYSCOM QUANTICO VA	MAJ	MCSC
OPERATIONS OFF	COMBINED MCTSSA AT CAMPEN	LTCOL	MCSC
DEPUTY DIV DIR	COMBINED MCTSSA AT CAMPEN	MAJ	MCSC
GND C2/CSS PO	COMBINED MCTSSA AT CAMPEN	MAJ	MCSC
HEAD	M&RA HQMC (OFFICERS)	LTCOL	M&RA
HEAD	M&RA HQMC (OFFICERS)	LTCOL	M&RA
SYSTEMS ANALYST	M&RA HQMC (OFFICERS)	MAJ	M&RA
DIRECTOR	M&RA HQMC (OFFICERS)	LTCOL	M&RA
SYSTEMS ANAL	M&RA HQMC MOB BILLETS	CAPT	M&RA
HEAD, CPN	C4 DEPARTMENT HQMC	MAJ	C4
SATELLITE COMM OFFICER	C4 DEPARTMENT HQMC	MAJ	C4
INFO TECH MGMT OFFICER	C4 DEPARTMENT HQMC	MAJ	C4
SECTION HEAD	PP&O HQMC MGT HQ (OFFICR)	LTCOL	PP&O
DIRECTOR	MCSA MISSA	LTCOL	PP&O
CHIEF	MCI CO MB WASHDC	MAJ	TECOM
SYSTEMS INTEGRATION OFF	PERS MGT DIV HQMC (MM)	MAJ	M&RA
HEAD, RECORDS SECTION	PERS MGT SPT BR MCCDC	MAJ	MCCDC
SYSTEMS OFFICER	HQ,MC RCTG CMD - MCRC	MAJ	M&RA
MODELING & SIMULATION	HQ CO LFTCPAC	CAPT	TECOM
MAT MGMT OFFICER	MARCORLOGBASES	MAJ	MATCOM
OP ARCHITECTURE OFF	CG MCCDC	MAJ	MCCDC
MODEL SPT/DESIGN OFF	MAGTF STF TRNG PROG CNTR	CAPT	TECOM
COMM OFFICER/ISMO	MARINE CORPS WAR LAB	CAPT	MCCDC
HEAD, TRAINING READINESS	TRAINING & EDUCATION CMD	LTCOL	TECOM
MODEL SUPPORT/DESIGN	TRAINING & EDUCATION CMD	MAJ	TECOM
OIC, TECH SUPPORT SECTION	TRAINING & EDUCATION CMD	MAJ	TECOM
SECTION HEAD	TRAINING & EDUCATION CMD	LTCOL	TECOM
EMERGING TECH OFFICER	TRAINING & EDUCATION CMD	MAJ	TECOM
BNA SYSTEM SPONSOR	TRAINING COMMAND	MAJ	TECOM
OPS/PLAN OFF	MCCDC AUDIO VISUAL	CAPT	MCCDC
HEAD PLANS & REQR BR	MOBILIZATION BILLETS	LTCOL	M&RA
CURRICULUM COORDINATOR	C&SC MCU EDU COM	LTCOL	TECOM
AC/S, COMM & INFO SYS	MCB CAMPEN BASE COMM	COL	I&L
DATA SYSTEMS REQR OFF	CG MCCDC	MAJ	MCCDC

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LIST OF REFERENCES

Note	Reference
ASTD 2002	American Society for Training and Development, "About ASTD," [http://www.astd.org/virtual_community/about_astd/index.html], 4 December 2002.
Bassi 2000	Bassi, Laurie, J., et al, "Profiting from Learning: Do Firms' Investments in Education and Training Pay Off?," American Society for Training and Development, September 2000.
Becker 1975	Becker, Gary S., *Human Capital: A Theoretical and Empirical Analysis, with Special reference to Education*, 2d edition, National Bureau of Economic Research, 1975.
Bowman and Mehay 1999	Bowman, William R. and Mehay, Stephen L,. "Graduate Education and Employee Performance: Evidence from Military Personnel," *Economics of Education Review* 18, 1999, 453-463.
Branigan 2001	Branigan, Gregory A,. *The Effects of Graduate Education on the Retention and Promotion of Marine Corps Officers*, Master's Thesis, Naval Postgraduate School, Monterey, California, March 2001.
Cook 2002a	Cook, Glenn, Interview by author, Monterey, California, 9 October 2002.
Cook 2002b	Cook, Glenn, Interview by author, Monterey, California, 27 November 2002.
Dessler 1991	Dessler, Gary, *Personnel/Human Recourse Management*, 5th edition, Prentice Hall, 1991.
Esparza 2002a	Esparza, Jorge, "RE: ITM Graduates," Electronic message to author, Quantico, Virginia, 14 August 2002.
Esparza 2002b	Esparza, Jorge, "State of the SEP," Presentation to Marine students, Naval Postgraduate School, Monterey, California, 22 October 2002.
Hinchliffe 1987	Hinchliffe, K., "Public Sector Employment and Education," *Economics of Education: Research and Studies*, Pergamon Press, 1987, 224-227.
Housel 2002	Housel, Thomas, Interview by author, Monterey, California, 27 November 2002.
Housel and Bell 2001	Housel, Thomas and Bell, Arthur H., *Measuring and Managing Knowledge*, McGraw-Hill Irwin, 2001.
Kaufman and Keller 1994	Kaufman, Roger and Keller, John M., "Levels of Evaluation: Beyond Kirkpatrick," *Human Resource Development Quarterly*, Volume 5, Number 4, Winter 1994: 371-380.
Kiker 1971	Kiker, B. F., *Investment in Human Capital*," University of South Carolina Press, 1971.

Kirkpatrick 1975 — Kirkpatrick, Donald L., *Techniques for Evaluating Training Programs: A Collection of Articles from the Journal of the American Society for Training and Development*, American Society for Training and Development, 1975.

Kirkpatrick 1998 — Kirkpatrick, Donald L., *Evaluating Training Programs*, 2d edition, Barrett-Koehler Publishers, 1998.

Klinger 2002a — Klinger, Joey, Telephone interview by author, Washington D.C., 26 September 2002.

Klinger 2002b — Klinger, Joey, "RE: BEECs," Electronic message to author, Washington D.C., 22 August 2002.

Marine Corps 1993 — Marine Corps Order 1520.9F, "Special Education Program," 4 May 1993.

Marine Corps 1998 — Marine Corps Order P1610.7E, "Performance Evaluation System (PES)," 3 December 1998.

Marine Corps 1999a — Marine Corps Order 5311.1C "Total Force Structure Process," 14 January 1999.

Marine Corps 1999b — Marine Corps Order P1553.4A "Professional Military Education," 20 December 1999.

Marine Corps 2000 — Marine Administrative Message 214-00, "Special Education Program (SEP) Billet Education Evaluation Certificate (BEEC) Validation," 20 April 2000.

Marine Corps 2001 — Marine Administrative Message 335-01, "Special Education Program (SEP) Billet Education Validation," 19 July 2001.

Marine Corps 2002 — Marine Administrative Message 304-02, "MCBUL 1560. FY03 Special Education Program (SEP)," 31 May 2002.

MCCDC 2002 — Marine Corps Combat Development Command, "MCCDC Command Brief," [www.mccdc.usmc.mil/Command_Briefs/MCCDC_CMD_BRIEF_0205], 6 September 2002.

NPS 2002a — Naval Postgraduate School Instruction 1550.1B, "Guidelines for Conducting Curricular Reviews," 4 March 2002.

NPS 2002b — Programs Officer, "Educational Skill Requirements, Information System Technology Curriculum," [http://www.nps.navy.mil/code32/IST/ESR.htm], Naval Postgraduate School, 17 September 2002.

NPS 2002c — Programs Officer, "Information System Technology," [http://www.nps.navy.mil/code32/IST/IST%20Homepage.htm], Naval Postgraduate School, 17 September 2002.

Oser 2002 — Oser, Randy, Interview by author, Newport, Rhode Island, April 2002.

Phillips 1996 — Phillips, Jack J., "How much is the Training Worth?" *Training & Development*, April 1996.

Phillips 1997 — Phillips, Jack J., *Handbook of Training Evaluation and Measurement Methods*, Gulf Publishing, 1997.

Phillips 1998 — Phillips, Jack J., "The Return-on-Investment (ROI) Process: Issues and Trends," *Educational Technology*, July-August 1998, 7-14.

Pickering 1995 — Pickering, John David, *Process Value Estimation at Pacific Bell*, Master's Thesis, Naval Postgraduate School, Monterey, California, December 1995.

Rosen 1987 — Rosen, S., "Self-selection and Education," *Economics of Education: Research and Studies*, Pergamon Press, 1987, 298-299.

Schultz 1961 — See Schultz, Theodore W., "Investment in Human Capital," *American Economic Review* 51, March, 1961: 1-17; (reprinted in *Investment in Human Capital*, edited by B. F. Kiker, University of South Carolina Press, 1971: 3-21).

Solmon 1987 — Solmon, L. C., "The Range of Education Benefits," *Economics of Education: Research and Studies*, Pergamon Press, 1987 83-93.

Usan and Utoglu 1999 — Usan, Abdullah and Utoglu, Mustafa, *The Effects of Graduate Education on the Job Performance of Civilian Department of Defense Employees*, Master's Thesis, Naval Postgraduate School, Monterey, California, September 1999.

Wielsma 1996 — Wielsma, Ronald J., *An Analysis of Factors Affecting Promotion, Retention, and Performance for USMC Offices: A Graduate Education Perspective*, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1996.

Wise 1975a — Wise, David A., "Academic Achievement and Job Performance," *The American Economic Review*, June 1975.

Wise 1975b — Wise, David A., "Personal Attributes, Job Performance, and Probability of Promotion," *Econometria*, Volume 43, No. 5-6, September-November 1975.

Woodhall 1987a — Woodhall, M., "Earnings and Education," *Economics of Education: Research and Studies*, Pergamon Press, 1987, 209-217.

Woodhall 1987b — Woodhall, M., "Human Capital Concepts," *Economics of Education: Research and Studies*, Pergamon Press, 1987, 21-24.

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